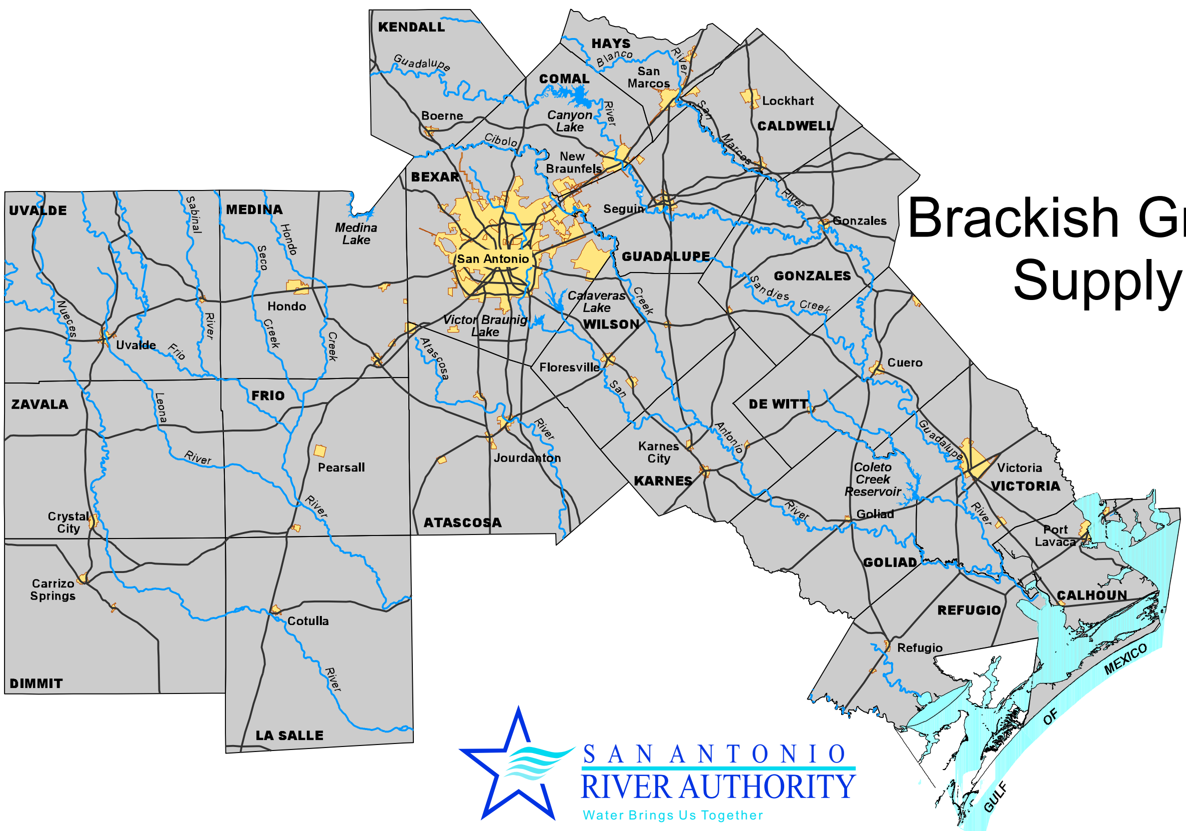
Region L

South Central Texas Regional Water Planning Group

2011 Regional Water Plan



Study 2
Brackish Groundwater Supply Evaluation

April 2009

SAN ANTONIO RIVER AUTHORITY
Water Brings Us Together

Prepared by:

South Central Texas Regional Water Planning Group

With administration by:

San Antonio River Authority

With technical assistance by:

HDR Engineering, Inc.
Laura Raun Public Relations
Ximenes & Associates

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South Central Texas Regional Water Planning Area

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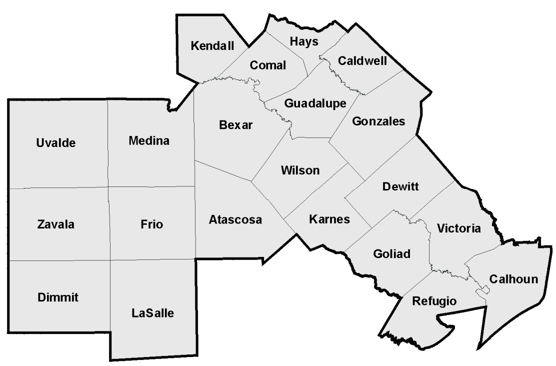

With technical assistance by:

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Executive Summary

ES.1 Introduction

The scope of this evaluation of brackish groundwater supplies water management strategies includes: (1) the Gulf Coast Aquifer with projects in southern Calhoun County and Refugio County for the City of Woodsboro and potential developments near Copano Bay; and (2) the Wilcox and Edwards Aquifers in the vicinity of southern Bexar County for municipal supplies in Bexar County. These three aquifers and diverse locations were related, in part, as illustrative examples for evaluation of brackish groundwater as municipal water supply. Evaluations of these water management strategies are intended to demonstrate the range of technical considerations and potential costs associated with development of this water source in Region L.

Based on preliminary information on brackish groundwater and water supply needs in the three areas of interest, the following four strategies were identified for the use of brackish groundwater. They are:

- Gulf Coast Aquifer in southern Calhoun County for potential new development in the vicinity of Seadrift and Port O'Connor;
- Gulf Coast Aquifer in southeastern Refugio County that would replace the conventional groundwater supply for the City of Woodsboro and potential new developments near Copano Bay;
- Wilcox Aquifer in Bexar, Atascosa and Wilson Counties to provide supplemental water to SAWS (Bexar County); and
- Edwards Aquifer from southern Bexar County to provide supplemental water to SAWS (Bexar County).

ES.2 Southern Calhoun County Groundwater Desalination Project

The Southern Calhoun County Groundwater Desalination Project is a strategy to supply potable water for potential coastal residential developments in the vicinity of Seadrift and between Seadrift and Port O'Connor (Figure ES-1). Based on a preliminary study by the Guadalupe-Blanco River Authority, the average daily demand for these developments is expected to reach 4.72 MGD by 2050, or 5,287 acft/yr. The peak day demand is estimated to be 11.8 MGD. Along with a water management strategy for full development, two contingency plans are provided. One is at half scale of full development plans and the other is at quarter scale.

A compilation of well data from the TWDB database shows high capacity wells in the vicinity of Seadrift to have depths between 250 and 350 ft and potential well yields between 600 to 1,000 gpm. The data show the concentration of chloride (Cl) and total dissolved solids (TDS) to commonly be in the 800 to 2,000 mg/L and 1,500 to 4,000 mg/L ranges, respectively.

The strategy includes the construction of new wells, water treatment plant, transmission of raw well water to the water treatment plant, storage, transmission to the residential developments, and disposal of concentrate. During a peak day of operation, the desalination water treatment plant will produce about 3.46 MGD of concentrate with a total dissolved solids (TDS) concentration of about 8,000 mg/L. This concentration is slightly less than the median salinity of about 10,000 mg/L of water in San Antonio Bay near Seadrift.

The primary environmental issue related to the project is the operation of a concentrate pipeline from the desalination water treatment plant to San Antonio Bay and its discharge into the waters of San Antonio Bay. Plans are for the concentrate from the desalination plant to be no more saline than the bay water under most conditions. The discharge of desalination concentrate into the bay may require multiple outfall locations or installation of a diffuser system to avoid localized differences in water quality.

Based on the loss of raw water to concentrate in the desalination process, the well field capacity will need to be about 15.26 MGD. For this feasibility level design and with a 20 percent contingency, 19 wells are needed for the full-scale project. The preliminary water treatment design has all the water undergoing removal of iron and manganese, about 91 percent of the raw well water will be sent to the desalination plant to remove inorganic and organic water quality constituents; and, the remaining 9 percent will be blended with the desalinated water. Based on a conventional reverse osmosis (RO) desalination process, the desalination plant recovery rate is estimated to be 75 percent, meaning that 75 percent of the water entering the desalination plant passes through as purified water and 25 percent of the water becomes a brine. The desalinated water is blended back with the raw brackish water to produce finished water.

The full-scale project could provide an average daily demand of 5,287 acft/yr with capacity for peak day demands at an annual unit cost of $1,661 per acft/yr. The average annual demands for the half and quarter-scale projects are 2.36 and 1.18 MGD (2,644 and 1,321 acft/yr), respectively. The half-scale project could provide treated water at an annual unit cost of $1,890 per acft/yr. The quarter-scale project could provide water at an annual unit cost of $2,160 per acft/yr.

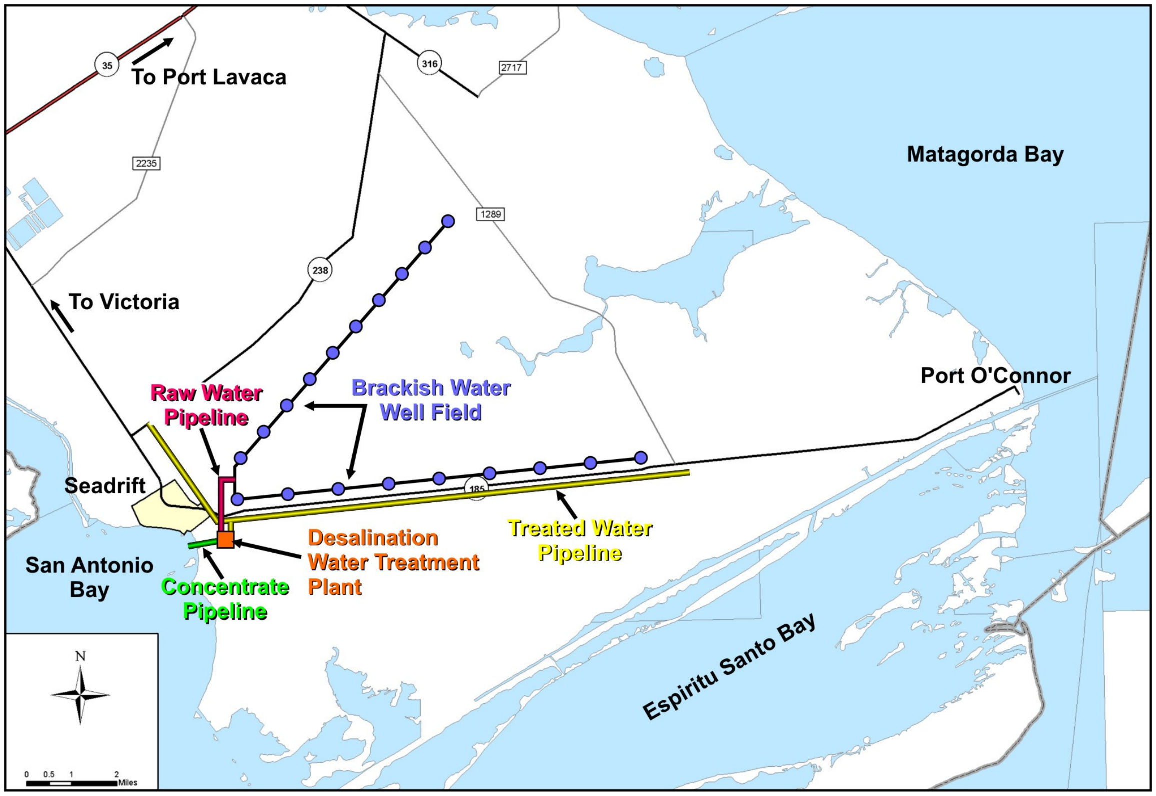


Figure ES-1. Southern Calhoun County Brackish Groundwater Desalination Project

ES.3 Woodsboro-Copano Bay Brackish Groundwater Desalination Project

The Woodsboro-Copano Bay Brackish Groundwater Desalination Project strategy is conceptually designed to meet two needs. One is a replacement of current and future potable water supplies for the City of Woodsboro, and the other is to provide water for projected future demands from potential coastal residential developments in the vicinity of Copano Bay (Figure ES-2). The City of Woodsboro has a reported average daily consumption is 0.203 MGD. For the Copano Bay area, population projections in the 2006 Region L Water Plan do not show major growth. However, the area may be subject to a substantial growth in population like southern Calhoun County. As an example for planning purposes, a strategy for projected water demands that is equivalent to the half–scale project for Southern Calhoun County Groundwater Desalination Project. Accordingly, average water demand is 2.36 MGD (2,644 acft/yr) will be developed for the Copano Bay developments. The Woodsboro and Copano water supply project is designed to provide an average daily supply of 2.58 MGD and a peak daily supply of 6.34 MGD.

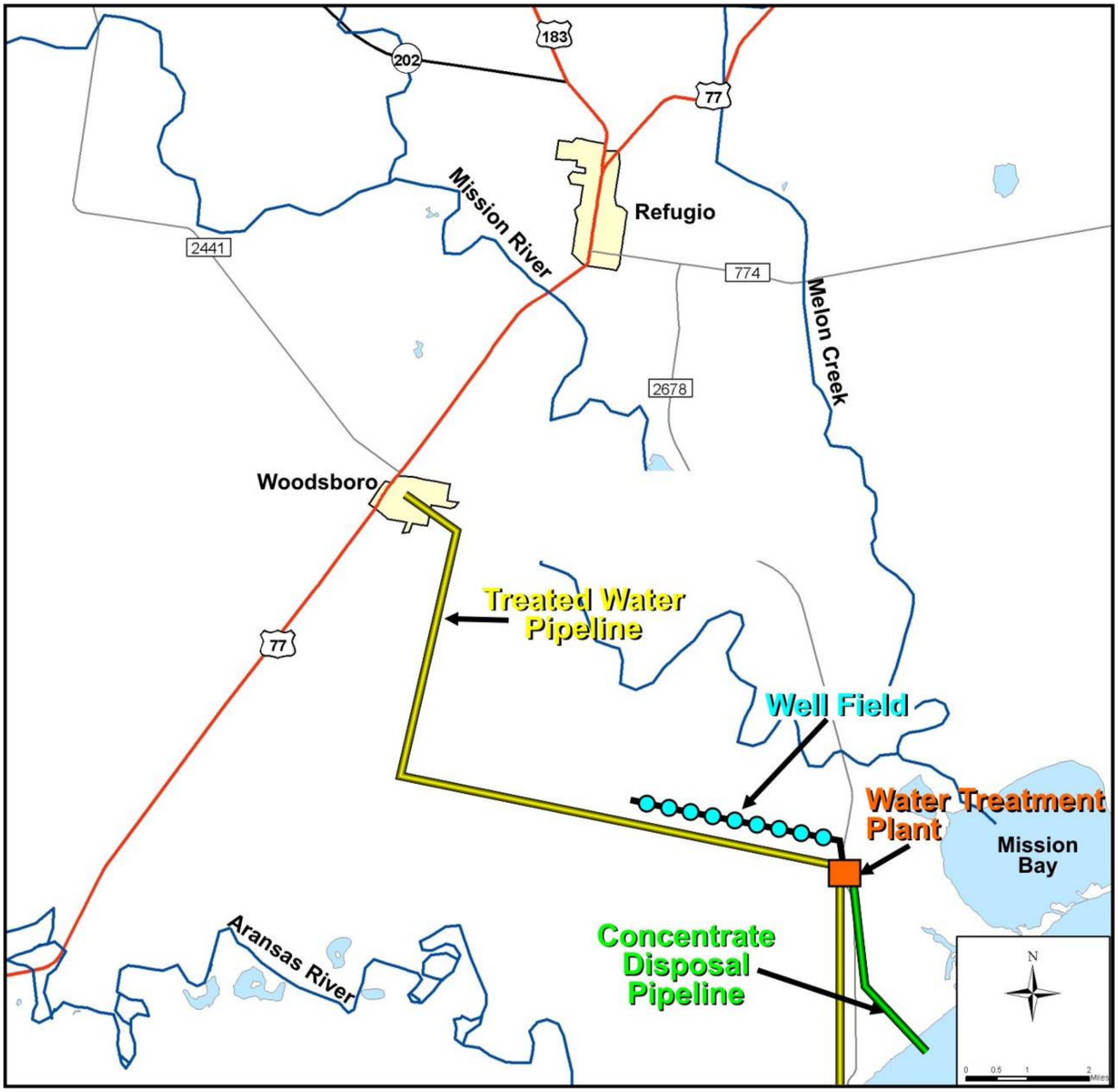


Figure ES-2. Woodsboro-Copano Bay Brackish Groundwater Desalination Project

The strategy includes the construction of new wells, water treatment facilities, transmission of raw well water to the water treatment plant, storage, distribution pipelines for treated water, and a disposal pipeline for concentrate. It does not include any distribution system replacements or expansions. Desalination facilities are to be sized to provide 88 percent of the potable water demands during peak day conditions. The remaining 12 percent will be treated raw water, which will be blended with the water from the desalination plant. The entire water treatment facility is to produce a finished blended water supply with a chloride (Cl) concentration less than 120 mg/L and TDS concentration of about 300 mg/L.

A compilation of well data shows well depths for high capacity wells in the vicinity of Copano Bay to be between 150 and 900 ft. Potential well yields range up to a 1,000 gpm. The concentration of Cl and TDS commonly are in the 300 to 500 mg/L and 900 to 1,400 mg/L ranges, respectively.

The primary environmental issue related to project is the operation of a concentrate pipeline from the desalination water treatment plant to Copano Bay. The discharge of desalination concentrate into Copano Bay may require multiple outfall locations or installation of a diffuser system to avoid high localized concentrations of some constituents. During a peak day of operation, the desalination water treatment plant could produce about 1.86 MGD with a TDS concentration of about 8,000 mg/L. This concentration is somewhat less than an expected, normal salinity of about 10,000 mg/L of water in Copano Bay.

Minimizing the potential for intrusion of poor quality water is accomplished by relatively wide well spacing and low pumping rates. Accordingly, wells will be spaced about a half mile apart; and well pumping will be set at a low to moderate rate, which is considered to be about 800 gpm. This spacing exceeds the minimum requirements of the RCGCD rules. In general terms, the rules require a well owner to hold ownership of groundwater rights sufficient for a production limit of no more than one-half acft/ac. To meet this rule, a well field producing an average of 1.22 MGD for a year (1,370 acft/yr) will require ownership ofgroundwater rights on 2,740 contiguous surface acres. To meet the peak day demands and to provide one backup well, a total of 9 wells would be required.

The conceptual design has 88 percent of the raw water from the well field being sent to the desalination plant to remove dissolved solids and the remaining 12 percent is later blended with the desalinated water. The desalination plant recovery rate is estimated to be 75 percent, meaning that 75 percent of the water entering the desalination plant passes through as purified water and 25 percent of the water remains as concentrated brine containing the constituents removed from the purified water.

The engineering and costing analysis includes a brackish well field with 9 wells with a production capacity of at least 6.34 MGD, a water treatment plant capable of producing 6.34 MGD with 1.86 MGD coming from the RO unit. The project requires about 15 miles of treated water pipeline, 4.5 mile of well field collection pipeline, and about 5 miles of pipeline to discharge the concentrate. Pipeline diameters range from 10 to 24 inches. This brackish groundwater desalination strategy could provide an average daily supply of 2,891 acft/yr with capacity for peak day demands at an annual unit cost of $2,054 per acft/yr.

ES.4 SAWS Local Wilcox Desalination Project

The SAWS Local Wilcox Desalination Project is a water supply strategy based on the development of brackish groundwater from the Wilcox Aquifer in southern Bexar, northern Atascosa, and western Wilson Counties (Figure ES-3). SAWS is currently (August 2008) continuing with research to better characterize the Wilcox Aquifer as a potential source water in terms of availability and water quality. The strategy is to produce 28,000 acft/yr (25 MGD) of potable water and deliver all of the water to the west side of San Antonio. Preliminary design for this strategy includes: three well fields that draw water from the Wilcox Aquifer, collection and transmission pipelines to deliver raw water to the water treatment plant, a desalination water treatment plant, and transmission facilities to deliver the treated water to a major distribution center (Anderson Pump Station), transmission facilities to dispose of backwash water from filter maintenance, and transmission facilities and deep wells to dispose of concentrate from the water treatment plant.

Preliminary analyses of test data collected by SAWS show high capacity Wilcox wells in this area would need to be 1,500 to 3,000 ft deep and have potential yields between 800 and 1,000 gpm. The data also show the TDS concentrations to be in the 1,300 – 1,500 mg/L range. For purposes of this strategy, Wilcox Aquifer wells are assumed to have an average capacity of 800-1,000 gpm and to produce water with a TDS of 1,400 mg/L. Based on an analysis of the modeling results, plans are for the well fields will have a total of 27 wells and have a well spacing of about 4,000 ft.

The primary environmental issues are well fields, water treatment, integration into the SAWS water distribution system in northwest San Antonio, and disposal of backwash and concentrate. Separate disposal pipelines and facilities are planned for concentrate and backwash water. The concentrate from the RO unit will be disposed of by deep well injection in a depleted oil and gas field.

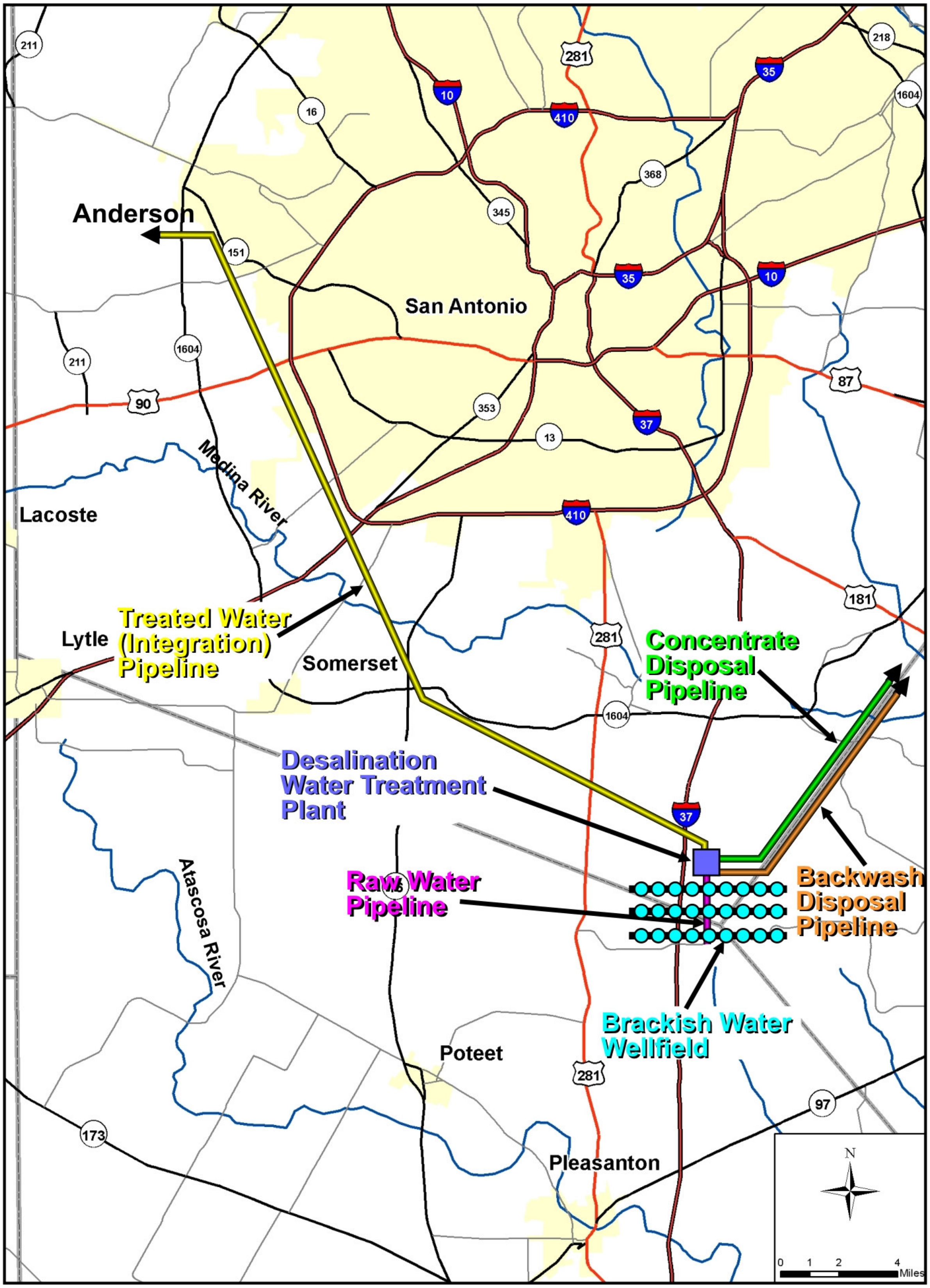


Figure ES-3. SAWS Local Wilcox Desalination Project

The engineering and costing analyses include all facilities required for water production from the Wilcox Aquifer in Bexar, Atascosa, and Wilson Counties, water treatment, delivery to SAWS water distribution system in northwest San Antonio, and disposal of backwash and concentrate. Desalination water treatment is planned to use Reverse Osmosis (RO) technology and will be located in south Bexar County. Finished water will be pumped to Anderson Pump Station in northwest San Antonio. Separate disposal pipelines and facilities are planned for concentrate and backwash water.

The engineering and costing analysis provided by SAWS includes a brackish well field with 27 wells with a production capacity of about 30 MGD. The raw water collection pipelines will vary in diameter and be about 20 miles long. The raw water transmission pipelines will be about 19 miles long. The project's integration pipeline from the water treatment plant to northwest San Antonio will be 36 inch in diameter and about 28 miles long and require a pump station in the vicinity of Lackland. SAWS plans for concentrate disposal include a pump station, a pipeline about 17 miles long and 6 deep injection wells. Finally, the backwash will require a pump station and a pipeline of about 14 miles long.

SAWS cost estimates for the project includes a total capital cost of $197,233,000 and a total project cost of about $299,233,000. Annual operating cost, including debt service, groundwater leases, and groundwater district fees, to be about $38,499,000. With a project yield of 28,000 acft/yr (25 MGD), the annual unit cost of water would be $1,375 per acft/yr.

For consistency in consideration of multiple water management strategies evaluated in the regional water planning process, an alternative cost estimate using standard Region L procedures and technical assumptions was prepared. This cost estimates shows a total capital cost of $175,033,000 and a total project cost of about $264,882,000. Annual operating cost, including debt service, groundwater leases, and groundwater district fees, to be about $33,364,000. With a project yield of 28,000 acft/yr (25 MGD), annual unit cost of $1,192 per acft/yr. Instances where the SAWS estimate is somewhat higher than Region L are: pipeline unit costs; water treatment plants; backwater disposal system; engineering, legal and contingencies; operation and maintenance of pump stations and pipelines; and power costs. Instances where the Region L estimate is higher than the SAWS estimate includes: pump stations; and environmental studies and mitigation. The Region L cost estimating procedures do not itemize the cost of disposing of backwash from the water treatment plants.

A potential adverse impact of the project is on the water levels in other aquifers. Accordingly, additional research on potential interaction between the Wilcox and Carrizo formations has been suggested.

Development of the project will require securing groundwater rights or the purchase of land for all the wells. In Atascosa and Wilson Counties, Evergreen Underground Water Conservation District's rules require permits for wells and groundwater export. Well spacing and production limits are to be determined from the results of a groundwater model, location of existing wells, location of the proposed well field and amount of production from the well field.

In summary, the cost estimate using Region L procedures shows the unit water cost to be about 13 percent lower than the SAWS estimate. This is not to say that one estimate is more accurate than the other estimate. Finally, it's important to note that SAWS is considering modifications to these plans and is conducting additional research on the feasibility and design of this strategy.

ES.5 Edwards Brackish Desalination Project

The Edwards Brackish Desalination Project is a water management strategy based on the development of brackish groundwater from the Edwards Aquifer in southern Bexar County (Figure ES-4). The concept of expanding use of the Edwards by pumping and treating brackish groundwater has been of interest to some water planners in Bexar County for many years. For this strategy, the target location of the well field was selected on the basis of placing the well field in the updip section of the saline part of the Edwards where there is a perceived separation from the freshwater part of the Edwards Aquifer, yet not so deep as to encounter very saline water and great well depths. The planned location for the well field is between Texas Highway 16 and U.S. Highway 281 south of Loop 1604. Treated water would be delivered to SAWS Anderson Pump Station.

The selected strategy is sized to produce 18,000 acft/yr (16 MGD). Preliminary design for this strategy includes: a well field that draws water from the brackish part of the Edwards Aquifer, collection pipelines for delivery of raw well water to the nearby desalination water treatment plant, water treatment plant, transmission facilities (storage, pipelines and pump stations) to deliver the treated water to the SAWS Anderson Pump Station, and transmission facilities and deep wells to dispose of concentrate from the water treatment plant.

One major topic of concern developed during the construction of a Edwards test well in the saline zone near the town of Lytle by SAWS. The test well began producing high levels of hydrogen sulfide gas during the drilling process. Because of safety concerns, the test well was immediately shut-in. Thus, a very limited amount of data was collected. The limited water quality data suggests sulfate concentrations were greater than 1,000 mg/L and TDS concentrations were about 2,000 mg/L. Another concern with the development of Edwards saline water is the potential for freshwater to move from the Edwards across the "Bad Water Line" and into the brackish well field. There are many faults in the area between the planned brackish well field and the freshwater zone of the Edwards; however, there is not sufficient information to explicitly determine what portion, if any, of the water budget from the brackish well field will come from the freshwater section of the Edwards Aquifer. However, considering the geology, hydrology, and water chemistry of the saline zone, it appears that, in time, the brackish well field will cause some freshwater to be lost from the Edwards Aquifer.

The engineering and costing analysis for this project includes all facilities required for water production from the Edwards Aquifer in southern Bexar County, water treatment, transmission to Anderson Pump Station, disposal of concentrate, and purchase of Edwards water rights. The well field consists of brackish water supply wells, collector pipelines, and raw water transmission facilities. Desalination water treatment is expected to use Reverse Osmosis (RO) technology and will be located adjacent to the well field. Finished water will be pumped to SAWS Anderson Pump Station. Following SAWS plans for their Local Wilcox Desalination Project, the concentrate will be injected into deep wells in the area.

The TDS concentration of the Edwards saline water is estimated to be about 4,500 mg/L. To approximate the TDS concentrations of fresh Edwards water, preliminary designs have 95 percent of the raw water from the well field being processed by the desalination component of the water treatment plant to remove dissolved solids and approximately 5 percent bypassing the RO units, which will be blended with permeate from the RO unit. The resulting water quality is about 300 mg/L of TDS. Considering water losses to concentrate from the RO process, the yield of the strategy is expected to be about 75 percent efficient. Thus, a 21 MGD well field is needed to produce 16 MGD of potable water. Pretreatment prior to the desalination process will include filtration and possibly other processes to condition the water for optimal desalination by RO.

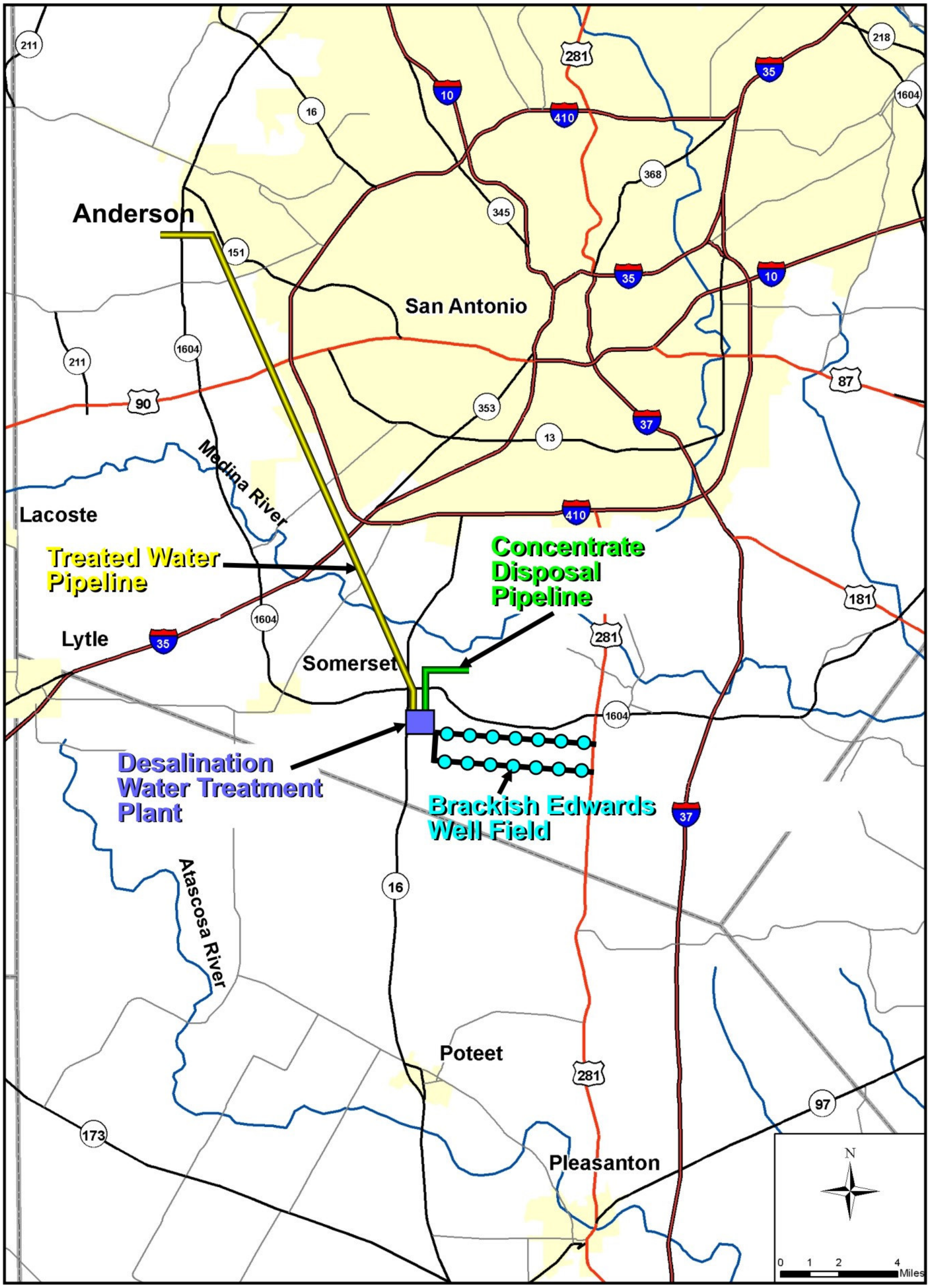


Figure ES-4. Edwards Brackish Desalination Project

The engineering and costing analyses include a brackish well field with 14 wells with a total production capacity about 21 MGD, a water treatment plant capable of producing 16 MGD with about 15 MGD coming from the RO unit. Preliminary plans are to operate the plant as a base load operation. Well pumps will be sized to deliver raw water directly to the water treatment plant. The treated water pipeline from the water treatment plant to the Anderson Pump Station will be 33 inches in diameter and about 21.9 miles long. Because of the Edwards is fully allocated by the EAA, costs for the purchase of existing water rights are included, which are estimated to be about $5,500 acft. The amount of water right that has to be purchased must allow for water that is lost to concentrate and an allowance for Edwards withdrawal cutbacks during the most severe conditions. This results in the requirement to purchase 39,325 acft of Edwards water, which is assumed to come from the San Antonio Pool. The disposal of concentrate is expected to require about 5 wells and an injection pump station. The total length of pipelines for disposal of concentrate is estimated to be about 18 miles long. The desalination of Edwards brackish groundwater strategy would require pumping about 23,600 acft of brackish water to provide an average daily demand of 18,000 acft/yr (16 MGD) and produce potable water at an estimated annual unit cost of $2,103 per acft/yr.

1.0 Description of Water Management Strategy Scenarios

In the Texas Water Development Board's report "Brackish Groundwater Manual for Texas Regional Water Planning Groups"[1], major and minor aquifers in Texas were evaluated for brackish water availability, productivity, and source water production cost. Availability of brackish groundwater is defined as a general measure of the amount of brackish water in a water-bearing zone. Productivity is a general measure of well field capacities. Source water production cost is an indication of the relative cost that would be incurred to produce brackish groundwater, excluding the treated water delivery, cost of treatment, and disposal of concentrate.

The scope of this evaluation of brackish groundwater supplies for water management strategies includes the Gulf Coast, Wilcox, and Edwards Aquifers. For this study, brackish groundwater is defined as groundwater with salinity greater than secondary drinking water standards (500 ppm Cl and 1,000 ppm TDS) and less that 5,000 ppm TDS, while saline groundwater is groundwater with salinity greater than 5,000 ppm TDS. Based on preliminary information on brackish groundwater and water supply needs in the three areas of interest, the following four strategies were developed for the use of brackish groundwater. They are:

- Gulf Coast Aquifer in southern Calhoun County for new development in the vicinity of Seadrift and Port O'Connor;
- Gulf Coast Aquifer in southeastern Refugio County that would replace the conventional groundwater supply for the City of Woodsboro and supply potential new developments near Copano Bay;
- Wilcox Aquifer in Bexar, Atascosa, and Wilson Counties to provide supplemental water to SAWS (Bexar County); and
- Edwards Aquifer from southern Bexar County to provide supplemental water to SAWS (Bexar County).

Selection of these three aquifers and diverse locations as examples for evaluation of brackish groundwater as municipal water supply is intended to demonstrate the range of technical considerations and potential costs associated with development of this water source in Region L.

A compilation of the general assessment of brackish groundwater by LBG-Guyton (2003) is shown in Table 1-1.

[1] LBG-Guyton Associates, "Brackish Groundwater Manual for Texas Regional Water Planning Groups," Texas Water Development Board, February 2003.

Table 1-1
General Assessment of Brackish Groundwater by Aquifer

Aquifer	***Availability***	***Productivity***	***Source Water Production Cost***
Edwards	High	Low-Moderate	Moderate-High
Carrizo-Wilcox	High	High	Moderate-High
Gulf Coast	Moderate	High	Low-Moderate

A study conducted by HDR Engineering Inc. (HDR) titled "Water Quality Characteristics of the Wilcox Aquifer in the Vicinity of San Antonio, TX"[2] for San Antonio Water System (SAWS) using readily available well and geologic data and reports evaluated the potential for a brackish groundwater source from the Wilcox Aquifer in the vicinity of Bexar County. The study indicated that slightly brackish groundwater was available.

[2] HDR Engineering, Inc., "Water Quality Characteristics of the Wilcox Aquifer in the Vicinity of San Antonio, TX," San Antonio Water System, July 2004.

2.0 Southern Calhoun County Groundwater Desalination Project

2.1 Description

The Southern Calhoun County Groundwater Desalination Project is a strategy to accommodate projected future demands from potential coastal residential developments in the vicinity of Seadrift and between Seadrift and Port O'Connor (Figure 2-1). Based on a preliminary study by the Guadalupe-Blanco River Authority (GBRA)[3], the average daily demand for these developments is expected to reach 4.72 MGD by 2050, or 5,287 acft/yr. The peak day demand is estimated to be 11.8 MGD. This strategy does not include possible expansion of the City of Seadrift and the Port O'Connor Municipal Utility District water supplies, which, according to the 2006 South Central Texas Regional Water Plan (SCTRWP), do not indicate needing additional water supplies. Along with a water management strategy for full development, two contingency plans are provided. One is at half and the other is at quarter scale of full development plans. This half-scale project has an average daily demand of 2.36 MGD (2,644 acft/yr) and a peak day demand of 5.9 MGD. The quarter-scale project has an average daily demand of 1.18 MGD (1,322 acft/yr) and a peak day demand of 2.95 MGD. It is noted that the estimated population of Seadrift from the Texas State Data Center in 2007 exceeds the projected population for 2010 in the 2006 Regional Water Plan.

The strategy includes the construction of new wells, water treatment plant, transmission of raw well water to the water treatment plant, storage, transmission to the residential developments, and disposal of concentrate. Desalination facilities are to be sized to provide 88 percent of the potable water demands. The remaining 12 percent will be treated raw water, which will be blended with the water from the desalination plant. The entire water treatment facility is to produce a finished blended water supply with a chloride (Cl) concentration less than 120 mg/L and total dissolved solids (TDS) concentration of about 300 mg/L. After water treatment, the blended potable water will be delivered to the new developments. The water treatment facility is planned near the City of Seadrift, primarily to accommodate the disposal of the concentrate to San Antonio Bay and to be near the major developments. The well field will be on spurs extending to the northeast and northwest from the water treatment plant.

[3] Hill, Tommy, 2008, Written communication from GBRA

2.2 Available Yield and Water Quality

According to the 2006 SCTRWP, the supply of groundwater from the Gulf Coast Aquifer in Calhoun County in 2010 is 2,940 acft/yr, of which 2,167 acft/yr was allocated. Some of these supplies are in another part of Calhoun County. Also, the supplies do not distinguish between freshwater and brackish water. Although there are no specific estimates of the availability of brackish groundwater supplies, they are believed to be considerably greater than the freshwater supplies and sufficiently large to accommodate this water supply strategy.

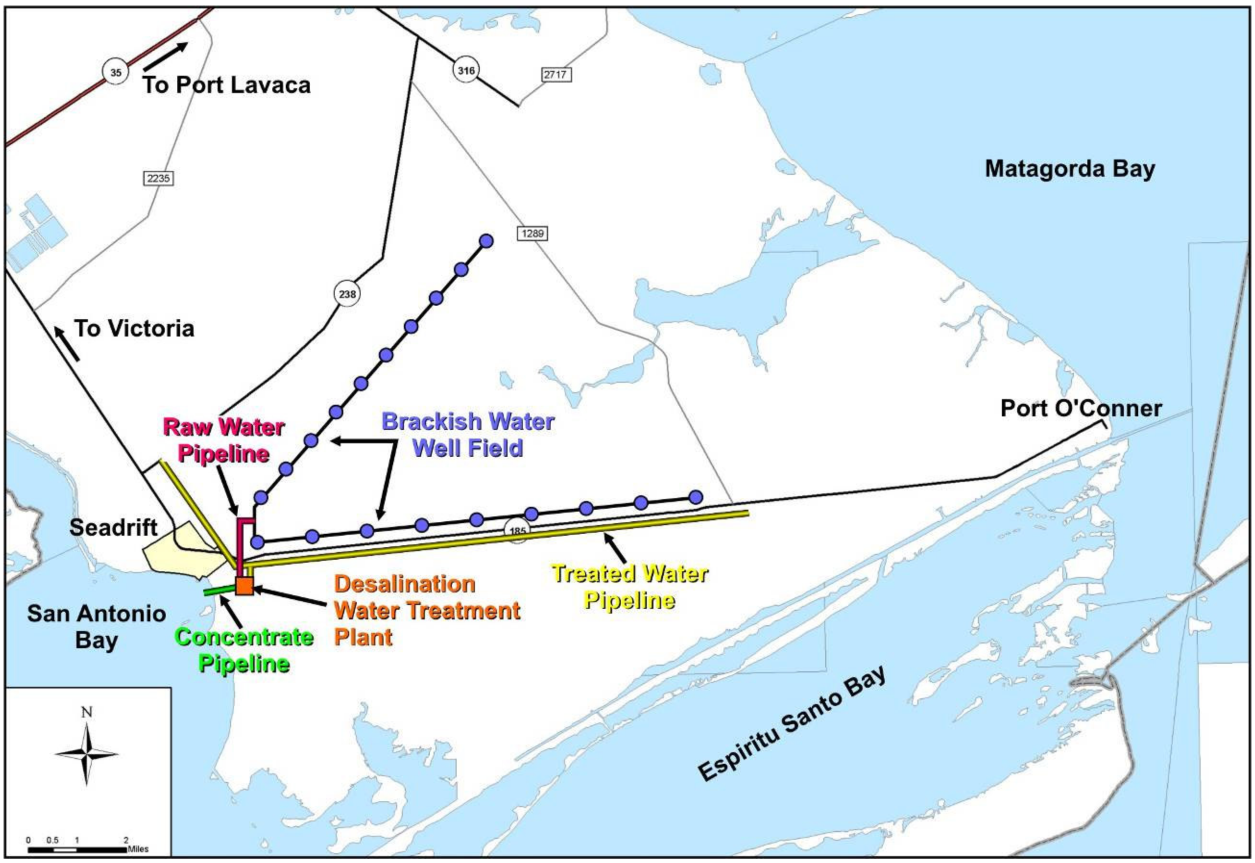


Figure 2-1. Southern Calhoun County Brackish Groundwater Desalination Project

A compilation of well data from the TWDB database shows high capacity wells in the vicinity of Seadrift to have depths between 250 and 350 ft and potential well yields between 600 to 1,000 gpm. The data show the concentration of Cl and TDS to commonly be in the 800 to 2,000 mg/L and 1,500 to 4,000 mg/L ranges, respectively. A review of water quality data for arsenic, iron, and manganese shows some wells producing water that exceeds EPA's Maximum

Contamination Level (MCL) or Texas secondary drinking water standards. A compilation and study of information from the TWDB well database (map in Appendix A) from oil and gas exploratory wells in the vicinity of Seadrift show little, if any, fresh groundwater. The deepest brackish groundwater appears to be about 400 ft below land surface. Below this depth, the water appears to be saline.

2.3 Environmental Issues

This strategy includes all facilities for the Southern Calhoun County Groundwater Desalination Project: brackish well field, collection and transmission of the raw water to the Seadrift water treatment plant, desalination, other treatment, and disposal of concentrate to San Antonio Bay. These features are all located in Omernik's[4] Western Gulf Coastal Plain ecoregion.

The primary environmental issue related to the project is the operation of a concentrate pipeline from the desalination water treatment plant to San Antonio Bay and its discharge into the waters of San Antonio Bay. Concentrate from desalination will be discharged to San Antonio Bay at a concentration that is no more than sea water. The discharge of desalination concentrate into the bay may require multiple outfall locations or installation of a diffuser system to avoid high localized concentrations.

Potential environmental effects resulting from the construction of a brackish groundwater desalination plant in the vicinity of San Antonio Bay will be sensitive to the siting of the plant and its concentrate discharge pipeline location. Construction will temporarily disrupt shoreline and benthic habitats in the immediate vicinity, including wetlands and other sensitive areas. Of particular concern will be potential impacts to *Spartina* marshes and to seagrass beds. Discharge sites may be selected to avoid oyster reefs and areas where organisms tend to concentrate. These include rock outcrops, man-made structures, the vicinities of tidal passes and the surf zone. It can be assumed that the permitting process will require a demonstration that the design of the discharge structure will be adequate to rapidly disperse the brine plume to ambient salinities within a relatively small mixing zone.

Table 2-1 lists the 30 state listed endangered and threatened species, and the 15 federally listed endangered or threatened wildlife and plant species that may occur in Calhoun County,

[4] Omernik, J. M, "Ecoregions of the conterminous United States," Annals of the Association of American Geographers, 77: 118-125, 1987.

Table 2-1.
Important Species* Having Habitat or Known to Occur in Calhoun County which Could be Potentially Affected by the Southern Calhoun County Groundwater Desalination Project

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
American Eel	*Anguilla rostrata*	Moist aquatic habitats			Resident
Atlantic Hawksbill Sea turtle	*Eretmochelys imbricata*	Gulf and bay system.	LE	E	Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large Bodies of water with nearby resting sites	DL	T	Nesting/Migrant
Black Bear	*Usus americanus*	Mountains, broken country, woods, brushlands, forests	T/SA; NL	T	Historic Resident
Black-Spotted Newt	*Notophthalmus meridionalis*	Ponds and resacas in south Texas		T	Resident
Brown Pelican	*Pelecanus occidentalis*	Coastal inlands for nesting, shallow gulf and bays for foraging	LE	E	Nesting/Migrant
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams			Resident
Eskimo curlew	*Numenius borealis*	Historic; grasslands, pastures	LE	E	Nonbreeding Historic Resident
Green Sea Turtle	*Chelonia mydas*	Gulf and bay system.	LT	T	Migrant
Gulf Saltmarsh Snake	Nerodia clarkii	Brackish to saline coastal waters			Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields, cut over areas.			Nesting/Migrant
Jaguarundi	*Herpailurus yaguarondi*	South Texas thick brushlands, favors areas near water	LE	E	Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Gulf and bay system.	LE	E	Migrant
Leatherback Sea Turtle	*Dermochelys coriacea*	Gulf and bay system.	LE	E	Migrant
Loggerhead Sea Turtle	*Caretta caretta*	Gulf and bay system.	LT	T	Migrant
Louisiana Black Bear	*Ursus americanus luteolus*	Within historical range.	LT	T	Historic Resident
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts			Nesting/Migrant
Ocelot	*Leopardus pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	LE	E	Resident

Table 2-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
Opossum Pipefish	*Microphis brachyurus*	Brooding adults found in fresh or low salinity waters.		T	Resident
Peregrine falcon	*Falco peregrinus anatum (American)*	Open county; cliffs	DL	E	Nesting/Migrant
	Falco peregrinus tundrius *(Arctic)*		DL	T	
Piping Plover	*Charadrius melodus*	Beaches and flats of Coastal Texas	LT	T	Migrant
Pistolgrip	*Tritogonia verrucosa*	Aquatic, stable substrate			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas and tallgrass prairie.			Resident
Red Wolf	*Canis rufus*	Extirpated.	LE	E	Historic Resident
Reddish Egret	Egretta rufescens	Coastal inlands for nesting, coastal marshes for foraging		T	Migrant
Sheep Frog	*Hypopachus variolosus*	Deep sandy soils of Southeast Texas		T	Resident
Snowy Plover	*Charadrius alexandrinus*	Wintering Migrant on mud flats.			Migrant
Sooty Tern	*Sterna fuscata*	Catches small fish.		T	Resident
Southeastern Snowy Plover	*Charadrius alexandrinus tenuirostris*	Texas Gulf Coast beaches and bayside mud or salt flats			Wintering Migrant
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Bays, coastal marshes of the upper two-thirds of Texas Coast			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush		T	Resident
Texas Scarlet Snake	*Cemophora coccinea lineri*	Mixed hardwood scrub		T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory; open grass/bare ground avoided.		T	Resident
Threeflower broomweed	*Thurovia triflora*	Endemic, tidal flats			Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	Resident

Table 2-1 (Concluded)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
West Indian manatee	*Trichechus manatus*	Aquatic	LE	E	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna			Resident
Western Snowy Plover	*Charadrius alexandrinus nivosus*	Winters along coast			Potential Migrant
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes.		T	Resident
White-tailed Hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes in Gulf coastal plain		T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Migrant
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant

- LE/LT=Federally Listed Endangered/Threatened
- E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearance
- DL, PDL=Federally Delisted/Proposed for Delisting
- E, T=State Listed Endangered/Threatened
- Blank = Rare, but no regulatory listing status

Source: TPWD, Annotated County List of Rare Species, Calhoun County, August 14, 2007.

according to county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species." Inclusion in Table 2-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area county. In addition to the county list, the Natural Diversity Database (NDD) map data was reviewed for known occurrences of listed species within or near the project area. This database documents occurrences of two species including threeflower broomweed (*Thurovia triflora*), a rare plant endemic to tidal flats, and the state and federally listed endangered Whooping Crane (*Grus Americana*), a migrant to the Texas coast.

Many migratory birds are dependent on the quality of estuarine environments in order to complete their foraging and nesting requirements during migration. One of the most well known of these migratory birds is the Whooping Crane (*Grus Americana)*, which is listed as endangered by both United States Fish and Wildlife Service (USFWS) and TPWD. A growing population of whooping cranes winter in and near the Aransas National Wildlife Refuge located adjacent to the

Mesquite Bay and the southern and western portions of San Antonio Bay. This wintering population has grown from a low of only 16 birds in 1941 to a high of 257 birds in December 2007. Detailed research studies by Texas A&M University are underway at this time to identify and better understand factors affecting whooping crane population. Three other migratory birds known to the San Antonio Bay area are listed as threatened by TPWD: the reddish egret (*Egretta rufescens*), wood stork (*Mycteria Americana*), and piping plover (*Charadrius melodus*). The piping plover is also listed as threatened by USFWS.

Several species listed as threatened by the state may possibly be affected. These include the Texas horned lizard (*Phrynosoma cornutum)*, Texas scarlet snake (*Cemophora coccinea* lineri), Texas tortoise (*Gopherus berlandieri)*, and timber/canebrake rattlesnake (*Crotalus horridus)*. Many of these reptile species are dependent on shrubland or riparian habitat. The opossum pipefish (*Microphis brachyurus*), also a state threatened species, requires fresh or low salinity waters for brooding and could be affected by salinity changes.

The presence or absence of potential habitat does not confirm the presence or absence of a listed species. Surveys for protected species should be conducted within the proposed construction corridors where preliminary evidence indicates their existence. No species specific surveys were conducted in the project area for this report.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291).

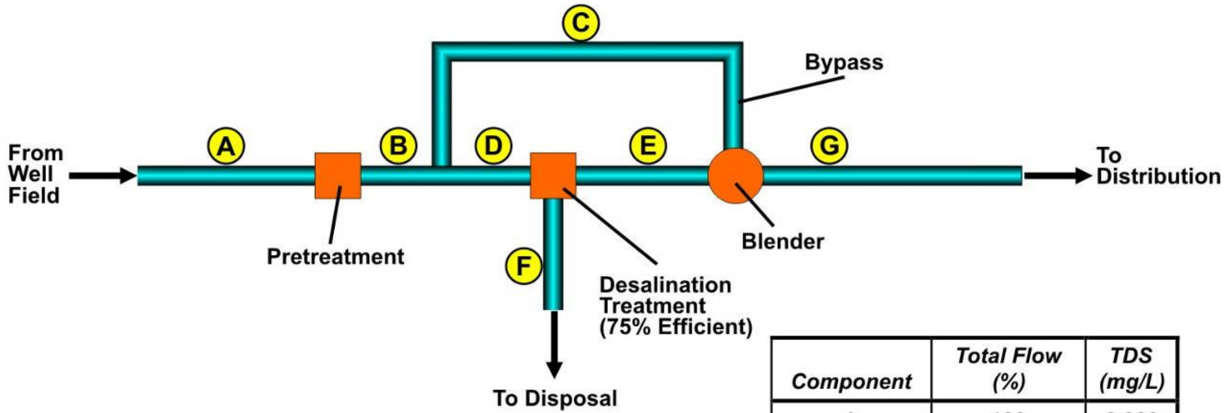
2.4 Engineering and Costing

The full size Southern Calhoun County Groundwater Desalination Project is designed to provide an average daily supply of 4.72 MGD and to meet a peak daily demand of 11.8 MGD. During a peak day of operation, the desalination water treatment plant will produce about 3.46 MGD of concentrate with a TDS concentration of about 8,000 mg/L. This concentration is less than a median TDS concentration of about 10,000 mg/L of water in San Antonio Bay.

A major consideration in selecting the location and design of a new well field is minimizing the potential for future intrusion of saline water. In general, saline water intrusion into a well in a hydrogeologic setting like southern Calhoun County can occur as upward migration from an underlying water-bearing strata or lateral migration. Saline water intrusion into a well field is most like to occur if the wells are very near a body of sea water, clustered in a small area, and pumped at high capacities. To minimize the chance of saline water intrusion over the planning period, the proposed wells will be located at least 2 miles inland from the nearest coast line; wells will be spaced about 1-mile apart; and, enough wells will be included for pumping rates to be at set at moderate levels, which is considered to be about 700 gpm.

In the proposed well field, the Cl and TDS concentrations may be 4 times greater than Texas Secondary Drinking Water Standards for Cl and TDS, which are 300 and 1,000 mg/L, respectively. The preliminary water treatment design has all the water undergoing removal of iron and manganese, about 91 percent of the raw well water will be sent to the desalination plant to remove inorganic and organic water quality constituents; and, the remaining 9 percent will be blended with the desalinated water. Based on a conventional reverse osmosis (RO) desalination process, the desalination plant recovery rate is estimated to be 75 percent, meaning that 75 percent of the water entering the desalination plant passes through as purified water and 25 percent of the water remains as concentrated brine. The desalinated water is blended back with the raw brackish water to produce the finished water. This process converts about 77 percent of the quantity of raw water produced from the well field into potable water. The remaining 23 percent is a concentrate and is discharged to San Antonio Bay. The blended finished water is expected to have a chloride and TDS concentrations of about 120 and 300 mg/L, respectively. Figure 2-2 is provided to illustrate the water treatment system, the percent of water flowing through each component of the system, and the concentration of the total dissolved solids.

Based on the loss of raw water to concentrate in the desalination process, the well field capacity will need to be about 15.3 MGD. For this feasibility level design and with a 20 percent contingency, 19 wells are needed for the full-scale project, 10 wells for a half-scale project, and 5 wells for the quarter-scale project. The length of the pipeline collecting the raw water from the well field will need to be about 19 miles long for the full-scale project, 10 miles for the half-scale project, and 4 miles for the quarter-scale project. The pipeline diameters vary from 12 to 20 inches. Well pumps will be sized to deliver the raw water directly to the water treatment plant. The integration pipeline to the developments will be about 15 miles long and have a diameter of 27 inches for the full-scale project, 18 inches for the half-scale project, and 16 inches for the quarter-scale project. The pipeline for discharging the concentrate to San Antonio Bay is estimated to be about 1 mile long and have a diameter of 16 inches for the full size development. It is designed with a diffuser to prevent localized concentrations of the concentrate in the bay. The location of the facilities is shown in Figure 2-1.



Component	*Total Flow (%)*	*TDS (mg/L)*
A	100	2,000
B	100	2,000
C	12	2,000
D	88	2,000
E	66	0
F	22	8,000
G	78	300

Figure 2-2. Flow Diagram for a Desalination Water Treatment Plant

The cost estimate for the full size Southern Calhoun County Groundwater Desalination Project is shown in Table 2-2. The engineering and costing analysis includes a brackish well field with 19 wells with a production capacity of 15.3 MGD, a water treatment plant capable of producing 11.8 MGD, with 10.4 MGD coming from the RO unit and 1.4 coming from treated raw water. The average annual demand for the full-scale project is 4.72 MGD (5,287 acft/yr). The project will require about 15.3 miles pipeline for treated water. Collection pipelines for the well fields range from 19 miles for the full scale project to 5 miles for the quarter scale project. Pipeline diameters for the treated water range from 12 to 27 inches for the full scale project and 6 to 14 inches for the quarter scale project. Separate pump stations are required for the integration and concentrate pipelines. The project will also require a combination of ground storage and elevated storage tanks. As shown in Table 2-2, the full-scale Southern Calhoun County Groundwater Desalination Project could provide an average daily demand of 5,287 acft/yr with capacity for peak day demands at an annual unit cost of $1,661 per acft/yr.

Table 2-2.
Cost Estimate Summary for Southern Calhoun County Groundwater Desalination Project (Full Scale)
(Second Quarter 2007 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Distribution Pump Station and Storage at WTP	$3,497,000
Concentrate Pump Station and Storage at WTP	$329,000
Treated Water Pipeline (12-27 inch, 15.3 miles)	$5,663,000
Concentrate Pipeline (16 inch, 1 mile)	$298,000
Well Field Pipeline (12-20 inch, 19 miles	$5,756,000
Well Fields (19 Wells)	$6,741,000
Water Treatment Plant (Desalination, 10.4 MGD)	$18,722,000
Total Capital Cost	**$41,006,000**
Engineering, Legal Costs and Contingencies	$14,054,000
Environmental & Archaeology Studies and Mitigation	$921,000
Land Acquisition and Surveying	$1,272,000
Interest During Construction (1 years)	$2,291,000
Total Project Cost	**$59,544,000**
Annual Costs	
Debt Service (6 percent, 30 years)	$4,326,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$249,000
Water Treatment Plant	$3,601,000
Pumping Energy Costs (0.09 $/kW-hr)	$390,000
Purchase of Water	$211,000
Total Annual Cost	**$8,777,000**
Available Project Yield (acft/yr)	5,287
Annual Cost of Water ($ per acft)	$1,660
Annual Cost of Water ($ per 1,000 gallons)	$5.09

Cost estimates for the half-scale and quarter-scale projects are shown in Tables 2-3 and 2-4, respectively. The average annual demands for the half and quarter-scale projects are 2.36 and 1.18 MGD (2,644 and 1,321 acft/yr), respectively. Peak daily capacity will be 5.9 and 3.0 MGD, respectively. As shown in Table 2-2, the half-scale Southern Calhoun County Groundwater Desalination Project could provide an average daily demand of 2,644 acft/yr with capacity for peak day demands at an annual unit cost of $1,890 per acft/yr. As shown in Table 2-4, the quarter-scale Southern Calhoun County Groundwater Desalination Project could provide an average daily demand of 1,322 acft/yr with capacity for peak day demands at an annual unit cost of $2,160 per acft/yr.

2.5 Implementation Issues

Implementation of the Southern Calhoun County Groundwater Desalination Project strategy includes the following issues:

- Permitting desalination concentrate discharge to San Antonio Bay;
- Verification of the Gulf Coast Aquifer water quality for concentrations of the dissolved constituents such as TDS, chloride, sulfate, iron, and manganese;
- Brine Disposal Discharge Permits by TCEQ; and
- Purchase or lease of property for well field and coordination with landowners.

Table 2-3.
Cost Estimate Summary for Southern Calhoun County Groundwater Desalination Project (Half Scale) (Second Quarter 2007 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Distribution Pump Station and Storage at WTP	$2,257,000
Concentrate Pump Station and Storage at WTP	$179,000
Treated Water Pipeline (12-18 inch, 15.3 miles)	$4,591,000
Concentrate Pipeline (12 inch, 1 mile)	$238,000
Well Field Pipeline (12-24 inch, 10 miles	$3,274,000
Well Fields (10 Wells)	$3,548,000
Water Treatment Plant (Desalination, 5.2 MGD)	$10,631,000
Total Capital Cost	**$24,718,000**
Engineering, Legal Costs and Contingencies	$8,409,000
Environmental & Archaeology Studies and Mitigation	$687,000
Land Acquisition and Surveying	$948,000
Interest During Construction (1 years)	$1,391,000
Total Project Cost	**$36,153,000**
Annual Costs	
Debt Service (6 percent, 30 years)	$2,626,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$159,000
Water Treatment Plant	$1,909,000
Pumping Energy Costs (0.09 $/kW-hr)	$191,000
Purchase of Water	$106,000
Total Annual Cost	**$4,991,000**
Available Project Yield (acft/yr)	2,644
Annual Cost of Water ($ per acft)	$1,888
Annual Cost of Water ($ per 1,000 gallons)	$5.79

Table 2-4.
Cost Estimate Summary for Southern Calhoun County Groundwater Desalination Project (Quarter Scale)
(Second Quarter 2007 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Distribution Pump Station and Storage at WTP	$1,331,000
Concentrate Pump Station and Storage at WTP	$125,000
Treated Water Pipeline (6-14 inch, 15.3 miles)	$4,067,000
Concentrate Pipeline (8 inch, 1 mile)	$158,000
Well Field Pipeline (16 inch, 4 miles	$1,190,000
Well Fields (5 Wells)	$1,774,000
Water Treatment Plant (Desalination, 2.6 MGD)	$6,267,000
Total Capital Cost	**$14,912,000**
Engineering, Legal Costs and Contingencies	$5,008,000
Environmental & Archaeology Studies and Mitigation	$516,000
Land Acquisition and Surveying	$763,000
Interest During Construction (1 years)	$848,000
Total Project Cost	**$22,047,000**
Annual Costs	
Debt Service (6 percent, 30 years)	$1,602,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$96,000
Water Treatment Plant	$1,029,000
Pumping Energy Costs (0.09 $/kW-hr)	$70,000
Purchase of Water	$53,000
Total Annual Cost	**$2,850,000**
Available Project Yield (acft/yr)	1,322
Annual Cost of Water ($ per acft)	$2,156
Annual Cost of Water ($ per 1,000 gallons)	$6.62

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3.0 Woodsboro-Copano Bay Brackish Groundwater Desalination Project

3.1 Description

Woodsboro-Copano Bay Brackish Groundwater Desalination Project strategy is designed to meet two needs. One is a replacement of current and future potable water supplies for the City of Woodsboro, and the other is to provide water for projected future demands from potential coastal residential developments in the vicinity of Copano Bay (Figure 3-1). According a recent Texas Commission on Environmental Quality (TCEQ) Public Water System Report for the City of Woodsboro, this water utility has a total production capacity of 1.3 MGD. The reported average daily consumption is 0.203 MGD and serves a population of about 1,700. The utility's water treatment consists only of chlorination. From 2000 to 2060, the 2006 SCTRWP shows a growth in water demands of 8 percent for Woodsboro. By 2060, the demand would be 0.22 MGD. For the Copano Bay area, population projections in the 2006 Region L Water Plan do not show major growth. However, the area may be subject to a substantial growth in population, like the projections in southern Calhoun County. As an example for planning purposes, a strategy has been formulated for projected water demands equivalent to the half–scale project for Southern Calhoun County Groundwater Desalination Project. Accordingly, an average water supply of 2.36 MGD (2,644 acft/yr) will be considered for the potential Copano Bay developments. Using the same peak to daily average ratio of 2.0 for Woodsboro and 2.5 that was used for the southern Calhoun County project, the average and peak daily water demand for both projects would be 2.58 and 6.34 MGD, respectively.

The strategy includes the construction of new wells, water treatment facilities, transmission of raw well water to the water treatment plant, storage, distribution pipelines for treated water, and a disposal pipeline for concentrate. It does not include any distribution system replacements or expansions in Woodsboro. Desalination facilities are to be sized to provide 88 percent of the potable water demands. The remaining 12 percent will be treated raw water, which will be blended with the water from the desalination plant. The entire water treatment facility is to produce a finished blended water supply with a chloride (Cl) concentration less than 120 mg/L and total dissolved solids (TDS) concentration of about 300 mg/L. After water treatment, the blended potable water will be delivered to Woodsboro and new developments. The location of the Woodsboro-Copano Bay Brackish Groundwater Desalination Project is shown in Figure 3-1.

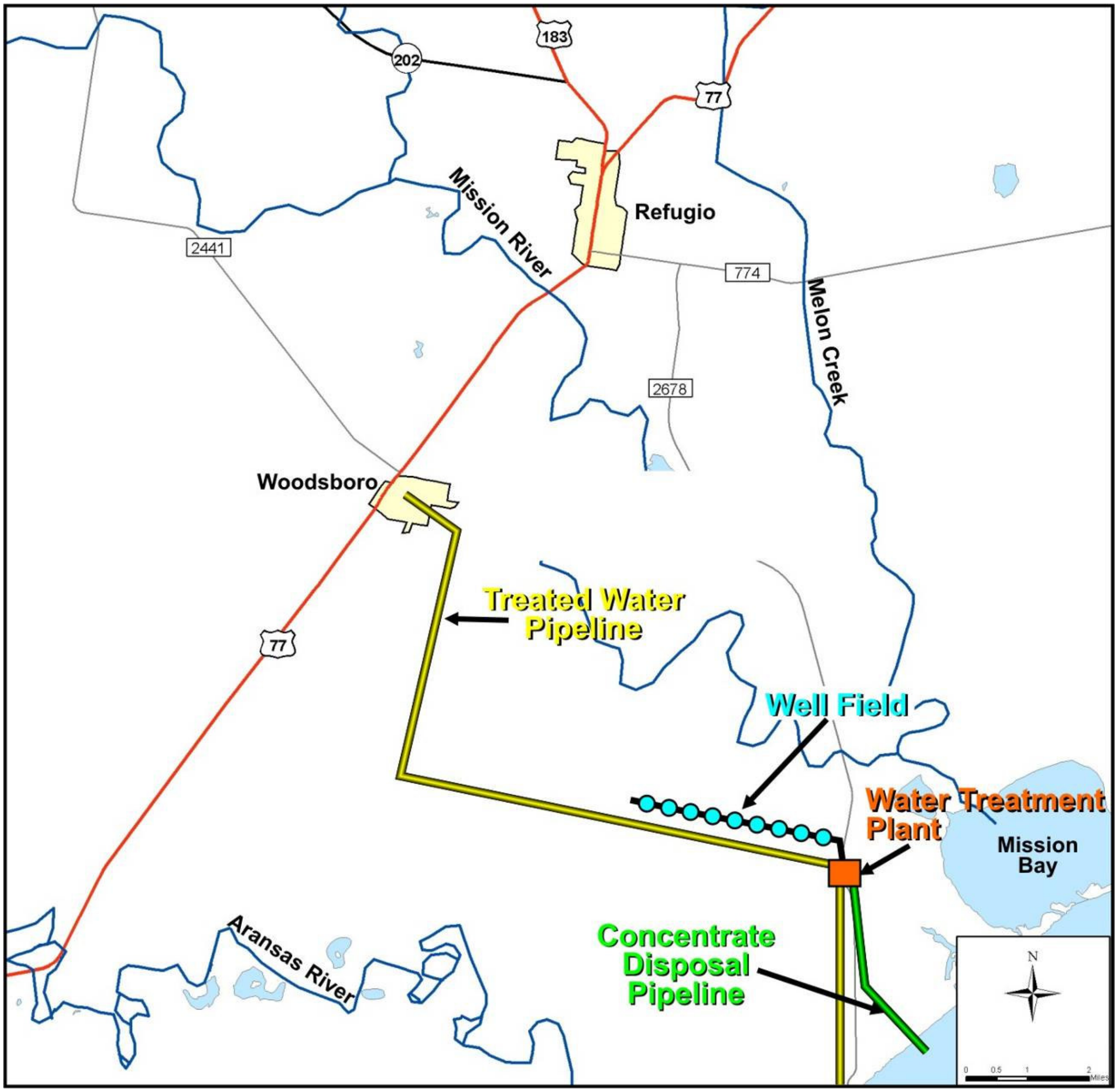

Figure 3-1. Woodsboro-Copano Bay Brackish Groundwater Desalination Project

3.2 Available Yield and Water Quality

According to the 2006 SCTRWP, the supply of groundwater from the Gulf Coast Aquifer in Refugio County is about 42,000 acft/yr, of which about 3,000 acft/yr is allocated. The Refugio Groundwater Conservation District (RGCD) management plan provides preliminary estimates of groundwater availability between 42,320 and 65,950 acft/yr. These supply estimates do not distinguish between freshwater and brackish water. But, freshwater supplies are known to diminish toward the coast. Although there are no specific estimates of the availability of brackish groundwater supplies, they are believed to be considerably greater than freshwater in the southeastern part of Refugio County and sufficient to supply water to this project.

A compilation of well data from the TWDB database shows well depths for high capacity wells in the vicinity of Copano Bay to be between 800 and 900 ft. Potential well yields range up to a 1,000 gpm. The concentration of Cl and TDS commonly are in the 800 and 1,100 mg/L and 1,400 to 2,100 mg/L ranges, respectively. A review of water quality data in the area also shows some wells produce water that exceeds EPA's Maximum Contamination Level (MCL) or Texas secondary drinking water standards for arsenic, iron, and manganese. Hydrogen sulfide and radiological contaminants also occur in groundwater from the Gulf Coast Aquifer.

3.3 Environmental Issues

This strategy includes all facilities for Woodsboro-Copano Bay Brackish Groundwater Desalination Project brackish well field, collection and transmission of the raw water to a water treatment plant at Woodsboro, desalination, other treatment, and transmission facilities to discharge the concentrate to Mission Bay. These features are located in Omernik's[5] Western Gulf Coastal Plain ecoregion.

The primary environmental issue related to Woodsboro-Copano Bay Brackish Groundwater Desalination Project is the operation of a concentrate pipeline from the desalination water treatment plant to Copano Bay. The discharge of desalination concentrate into Copano Bay may require multiple outfall locations or installation of a diffuser system to avoid high localized concentrations of some constituents.

Potential environmental effects resulting from the construction of a brackish groundwater desalination plant in the vicinity of Mission Bay will be sensitive to the siting of the plant and its concentrate discharge pipeline location. Construction will temporarily disrupt shoreline and benthic habitats in the immediate vicinity, including wetlands and other sensitive areas. Of particular concern will be potential impacts to *Spartina* marshes and to seagrass beds. Discharge sites may be selected to avoid oyster reefs and areas where organisms tend to concentrate. These include rock outcrops, man-made structures, the vicinities of tidal passes and the surf zone. It can be assumed that the permittng process will require a demonstration that the design of the

[5] Omernik, J. M, "Ecoregions of the conterminous United States," Annals of the Association of American Geographers, 77: 118-125, 1987.

discharge structure will be adequate to rapidly disperse the brine plume to ambient salinities within a relatively small mixing zone.

Table 3-1 lists the 31 state listed endangered and threatened species, and the 14 federally listed endangered or threatened wildlife and plant species that may occur in Refugio County, according to county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species." Inclusion in Table 3-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area county. In addition to the county list, Natural Diversity Database (NDD) map data was reviewed for known occurrences of listed species within or near the project area. This database documents occurrences of two rare species including Welder machaeranthera (*Psilactis heterocarpa*), a plant endemic to grasslands, and the Texas diamondback terrapin (*Malaclemys terrapin littoralis*), found in bays and coastal marshes of the Texas coast.

Many migratory birds are dependent on the quality of estuarine environments in order to complete their foraging and nesting requirements during migration. One of the most well known of these migratory birds is the Whooping Crane (*Grus Americana)*, which is listed as endangered by both USFWS and TPWD. A growing population of whooping cranes winter in and near the Aransas National Wildlife Refuge located adjacent to the Mesquite Bay and the southern and western portions of San Antonio Bay. This wintering population has grown from a low of only 16 birds in 1941 to a high of 257 birds in December 2007. Detailed research studies by Texas A&M University are underway at this time to identify and better understand factors affecting whooping crane population. Three other migratory birds known to the San Antonio Bay area are listed as threatened by TPWD: the reddish egret (*Egretta rufescens*), wood stork (*Mycteria Americana*), and piping plover (*Charadrius melodus*). The piping plover is also listed as threatened by USFWS.

One endangered species known to occur near the project area is the Attwater's greater prairie chicken (*Tympanuchus cupido attwateri*). This species prefers coastal prairies grassland areas with vegetation up to 24 inches in height. Several species listed as threatened by the state may possibly also be affected. These include the Texas horned lizard (*Phrynosoma cornutum)*, Texas scarlet snake (*Cemophora coccinea* lineri), Texas tortoise (*Gopherus berlandieri)*, and timber/canebrake rattlesnake (*Crotalus horridus)*. Several of these reptile species are dependent on shrubland or riparian habitat.

Table 3-1.
Important Species* Having Habitat or Known to Occur in Refugio County which Could be Potentially Affected by the Woodsboro-Copano Bay Brackish Groundwater Desalination Project

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
American Eel	*Anguilla rostrata*	Moist aquatic habitats			Resident
Atlantic Hawksbill Sea turtle	*Eretmochelys imbricata*	Gulf and bay system.	LE	E	Migrant
Attwater's Greater Prairie-chicken	*Tympanuchus cupido attwateri*	Endemic, open prairies and coastal plains	LE	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large Bodies of water with nearby resting sites	DL	T	Nesting/Migrant
Black lace cactus	*Echinocereus reichenbachii var albertii*	Openings in dense brush on sandy soils	LE	E	Resident
Black-Spotted Newt	*Notophthalmus meridionalis*	Ponds and resacas in south Texas		T	Resident
Brown Pelican	*Pelecanus occidentalis*	Coastal inlands for nesting, shallow gulf and bays for foraging	LE	E	Nesting/Migrant
Coastal gay-feather	*Liatris bracteata*	Endemic on black clay soils of prairie remnants			Resident
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams			Resident
Elmendorf's onion	*Allium elmendorfii*	Endemic, in deep sands			Resident
Golden orb	*Quadrula aurea*	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins			Resident
Green Sea Turtle	*Chelonia mydas*	Gulf and bay system.	LT	T	Migrant
Gulf Saltmarsh Snake	Nerodia clarkii	Brackish to saline coastal waters			Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields, cut over areas.			Nesting/Migrant
Indigo snake	*Drymarchon corais*	Dense riparian corridors		T	Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Gulf and bay system.	LE	E	Migrant
Leatherback Sea Turtle	*Dermochelys coriacea*	Gulf and bay system.	LE	E	Migrant
Loggerhead Sea Turtle	*Caretta caretta*	Gulf and bay system.	LT	T	Migrant
Louisiana Black Bear	*Ursus americanus luteolus*	Within historical range.	LT	T	Transient

Table 3-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields.			Nesting/Migrant
Ocelot	*Leopardus pardalis*	Dense chaparral thickets.	LE	E	Resident
Opossum Pipefish	*Microphis brachyurus*	Brooding adults found in fresh or low salinity waters.		T	Resident
Peregrine falcon	*Falco peregrinus anatum (American)*	Open county; cliffs	DL	E	Nesting/Migrant
	Falco peregrinus tundrius (Arctic)		DL	T	
Piping Plover	*Charadrius melodus*	Beaches and flats of Coastal Texas	LT	T	Migrant
Plains gumweed	*Grindelia oolepis*	Endemic, on prairies and grasslands on black clay soils			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas and tallgrass prairie.			Resident
Red Wolf	*Canis rufus*	Extirpated.	LE	E	Historic resident
Reddish Egret	Egretta rufescens	Coastal inlands for nesting, coastal marshes for foraging		T	Migrant
Rock pocketbook	*Arcidens confragosus*	Mud and sand, Red through Guadalupe River basins.			Resident
Sheep Frog	*Hypopachus variolosus*	Deep sandy soils of southeast Texas		T	Resident
Snowy Plover	*Charadrius alexandrinus*	Wintering Migrant on mud flats.			Migrant
Sooty Tern	*Sterna fuscata*	Catches small fish.		T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	Moderately open prairie-brushland			Resident
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Bays, coastal marshes of the upper two-thirds of Texas Coast			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush		T	Resident
Texas Scarlet Snake	*Cemophora coccinea lineri*	Mixed hardwood scrub		T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory; open		T	Resident
Tharp's rhododon	*Rhododon angulatis*	Deep sandy soils among and upon stabilized dunes			Resident

Table 3-1 (Concluded)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Threeflower broomweed	*Thurovia triflora*	Endemic, tidal flats			Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands		T	Resident
Welder machaeranthera	*Psilactis heterocarpa*	Endemic, grasslands and adjacent scrub flats on clay			Resident
West Indian manatee	*Trichechus manatus*	Aquatic	LE	E	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands.			Resident
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes.		T	Resident
White-nosed coati	*Nasua narica*	Woodlands, riparian corridors		T	Transient
White-tailed Hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes		T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Migrant
Wood Stork	*Mycteria americana*	Forages in shallow standing water		T	Migrant

- LE/LT=Federally Listed Endangered/Threatened
- DL, PDL=Federally Delisted/Proposed for Delisting
- E, T=State Listed Endangered/Threatened
- Blank = Rare, but no regulatory listing status

Source: TPWD, Annotated County List of Rare Species, Refugio County, October 30, 2007

The presence or absence of potential habitat does not confirm the presence or absence of a listed species. Surveys for protected species should be conducted within the proposed construction corridors where preliminary evidence indicates their existence. No species specific surveys were conducted in the project area for this report.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291).

3.4 Engineering and Costing

The Woodsboro-Copano Bay Brackish Groundwater Desalination Project is designed to provide an average daily supply of 2.58 MGD and a peak daily supply of 6.34 MGD. The strategy is to deliver about 0.22 MGD of the average daily supply to the City of Woodsboro and about 2.36 MGD to potential developments near Copano Bay. During a peak day of operation, the desalination water treatment plant will produce about 1.86 MGD with a total dissolved solids (TDS) concentration of about 8,000 mg/L. A diffuser is added for the concentrate pipeline to prevent localized concentrations of the effluent. This concentration from the desalination facility is somewhat less than an expected, normal TDS concentration in Copano Bay, which is about 10,000 mg/L. The project will require a peak raw groundwater supply of 8.20 MGD.

A major consideration in the location and design of a new or expanded well field is minimizing the potential for intrusion of poor quality water. This can be accomplished by relatively wide well spacing and low pumping rates. Accordingly, wells will be spaced about a half mile apart; and well pumping will be set at a low to moderate maximum rate, which is considered to be about 800 gpm. This spacing exceeds the minimum requirements of the RGCD rules. In general terms, the rules require a well owner to hold ownership of groundwater rights sufficient for a production limit of no more than one-half acft/ac. To meet this rule, a well field producing an average of 2.58 MGD for a year (3,677 acft/yr) will require the ownership of groundwater rights to 7,354 contiguous surface acres. To meet the peak day demands and to provide one backup well, a total of 9 wells are required.

Consideration was also given to constructing a deep injection well into oil and gas reservoirs that are locally used for brine disposal. Ultimately, the recommended plan is to discharge the concentrate into Copano Bay based on operational simplicity and reliability.

The engineering and costing analyses include a brackish well field, collection and transmission pipelines for raw water to the new water treatment plant, water treatment with a desalination process, distribution pipeline of treated water to Woodsboro and Copano Bay, and disposal of concentrate.

In the proposed well field, the Cl and TDS concentrations may be 4 times greater than Texas Secondary Drinking Water Standards for Cl and TDS, which are 300 and 1,000 mg/L, respectively. The preliminary water treatment design has all the water undergoing removal of iron and manganese, about 91 percent of the raw well water will be sent to the desalination plant to remove inorganic and organic water quality constituents; and, the remaining 9 percent will be blended with the desalinated water. Based on a conventional reverse osmosis (RO) desalination process, the desalination plant recovery rate is estimated to be 75 percent, meaning that 75 percent of the water entering the desalination plant passes through as purified water and 25 percent of the water remains as concentrated brine. The desalinated water is blended back with the raw brackish water to produce the finished water. This process converts about 77 percent of the quantity of raw water produced from the well field into potable water. The remaining 23 percent is a concentrate and is discharged to Copano Bay. The blended finished water is expected to have a chloride and TDS concentrations of about 120 and 300 mg/L, respectively.

The cost estimate for the Woodsboro-Copano Bay Brackish Groundwater Desalination Project is shown in Table 3-2. The engineering and costing analysis includes a brackish well field with 9 wells with a production capacity of at least 8.20 MGD, a water treatment plant capable of producing 6.34 MGD with 5.58 MGD coming from the RO unit. The average demand is estimated to be 2.58 MGD (2,891 acft/yr). The project will require about 15.3 miles of treated water pipelines, 4.5 miles of well field collection pipeline, and about 5 miles of pipeline to discharge the concentrate. Pipeline diameters range from 10 to 24 inches. A pump station is required for the distribution and concentrate pipelines. A storage tank is assumed to be part of the existing Woodsboro water system. Well pumps will be sized to deliver raw water directly to the water treatment plant. As shown in Table 3-2, the Woodsboro-Copano Bay desalination of brackish groundwater strategy will meet the identified demands at an annual unit cost of $2,054 per acft/yr.

Table 3-2.
Cost Estimate Summary for Woodsboro-Copano Bay
Brackish Groundwater Desalination Project
(Second Quarter 2007 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
Pump Stations and Storage at WTP	$1,907,000
Well Field Collection Pipelines (12-24 inches, 4.5 miles)	$1,467,000
Transmission Pipelines (10-20 inches, 15.3 miles)	$3,928,000
Concentrate Pipeline, with Diffuser (12 inches, 5 miles)	$1,558,000
Well Fields (9 Wells)	$5,081,000
Water Treatment Plant (Pretreatment and Desalination, 3.4 MGD)	$13,704,000
Total Capital Cost	**$27,645,000**
Engineering, Legal Costs and Contingencies	$9,401,000
Environmental & Archaeology Studies and Mitigation	$625,000
Land Acquisition and Surveying	$1,079,000
Interest During Construction (1 year)	$1,551,000
Total Project Cost	**$40,301,000**
Annual Costs	
Debt Service (6 percent, 30 years)	$2,928,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$168,000
Water Treatment Plant	$2,470,000
Pumping Energy Costs (0.09 $/kW-hr)	$223,000
Total Annual Cost	**$5,936,000**
Available Project Yield (acft/yr)	2,891
Annual Cost of Water ($ per acft)	$2,054
Annual Cost of Water ($ per 1,000 gallons)	$6.30

3.5 Implementation Issues

Implementation of the Woodsboro-Refugio Groundwater Desalination Project includes the following issues:

- Permitting desalination concentrate discharge to Copano Bay;
- Verification of the Gulf Coast aquifer water quality for concentrations of the dissolved constituents such as TDS, chloride, sulfate, iron, and manganese;
- Experience in operating and maintaining a desalination water treatment plant;
- Brine Disposal Discharge Permits by TCEQ;
- Procurement of groundwater rights or the purchase of contiguous property;
- Coordination with landowners; and
- Permitting from the groundwater conservation district.

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4.0 SAWS Local Wilcox Desalination Project

4.1 Description

The SAWS Local Wilcox Desalination Project is a water supply strategy based on the development of brackish groundwater in the Wilcox Aquifer in southern Bexar, northern Atascosa, and western Wilson Counties (Figure 4-1). SAWS is currently (December 2008) continuing with research to better characterize the Wilcox Aquifer as a potential source water in terms of availability and water quality. The target location of the well field was selected to minimize the length of the treated water pipeline and to utilize a more productive part of the Wilcox Aquifer. The desalination water treatment plant is to be adjacent to the well field and designed to treat the brackish water from the Wilcox Aquifer so that it is comparable to and compatible with water supplies from the Edwards and Carrizo Aquifer.

The current SAWS plan for this strategy is to produce 28,000 acft/yr (25 MGD) of potable water and deliver all of the water to the west side of San Antonio. Preliminary design for this strategy includes: well fields that draw water from the Wilcox Aquifer, collection and transmission pipelines to deliver raw water to the water treatment plant, a desalination water treatment plant, and transmission facilities to deliver the treated water to a major distribution center (Anderson Pump Station) on the west side of San Antonio, transmission facilities to dispose of backwash water from filter maintenance, and transmission facilities and deep wells to dispose of concentrate from the water treatment plant. Figure 4-1 illustrates the general layout of the facilities for the strategy.

4.2 Available Yield

A study by SAWS[6] of water well data and geophysical logs from oil and gas exploratory test holes identified a major source of brackish water in the Wilcox Aquifer in southern Bexar, northern Atascosa, and eastern Wilson Counties. Test drilling and field studies in the area by SAWS have greatly improved and refined the previous characterizations of the Wilcox Aquifer with regard to potential well yields and water quality. According to SAWS, analysis of data indicates a clear, discernable hydrogeologic division between the water-bearing sands in the Carrizo and Wilcox Aquifers. These data from test sites in southern Bexar County and northern

[6]Morrison, Kevin, 2008, Personal Communication.

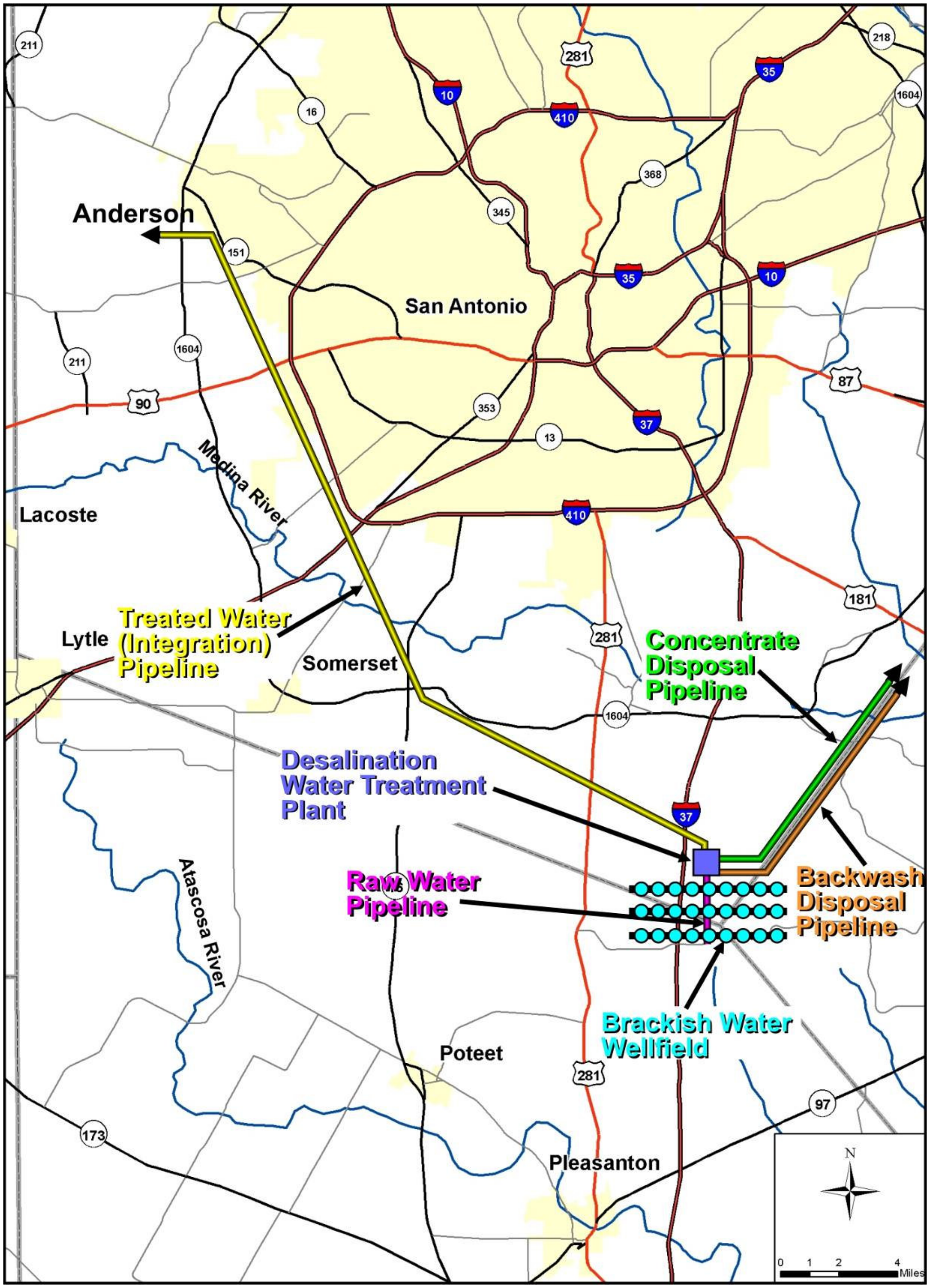

Figure 4-1. SAWS Local Wilcox Desalination Project

Atascosa County confirm that the upper Wilcox Formation is composed of intermixed shales and sands that act as an aquitard to isolate the major water-bearing zones of the Wilcox Aquifer from the overlying Carrizo Formation. Preliminary results suggest that well fields located in this area are suitable for a long-term supply of brackish groundwater.

Preliminary analyses of test data collected by SAWS and records of wells and oil and gas geophysical logs show high capacity Wilcox wells in this area would need to be 1,500 to 3,000 ft deep and have potential yields between 800 and 1,000 gpm. The data also show the TDS concentrations to be in the 1,300 – 1,500 mg/L range. For purposes of this strategy, Wilcox Aquifer wells are assumed to have an average capacity of 800 gpm and to produce water with a TDS of 1,400 mg/L. Preliminary groundwater modeling was conducted by a consultant to SAWS to develop guidance on well spacing, well yields, and drawdown. Based on an analysis of the modeling results, plans are for the well fields will have a total of 27 wells and have a well spacing of about 4,000 ft.

As of April 2008, a consultant to SAWS has conducted groundwater model simulations for well fields producing about 20 MGD[7]. The preliminary modeling results showed a drawdown around the well field of about 50 to 150 ft, with maximum drawdown at pumping wells of approximately 350 ft at the end of 50 years.

The procedure for obtaining groundwater supplies for the project is dependent on the procurement of groundwater rights from the land owner. In Bexar County, there is no groundwater district to regulate well spacing and production in the Wilcox Aquifer. In the past, SAWS has purchased sufficient property for well sites for the facilities and sanitary easements. In Atascosa and Wilson Counties, SAWS would have to purchase groundwater leases or sufficient land that would be necessary to conform to the rules of the Evergreen Underground Water Conservation District. According to the rules, the spacing and production of the wells are dependent on results of a groundwater model, location of the well field, distance to other wells, and the amount of requested water.

4.3 Environmental Issues

The primary environmental issues related to the SAWS Local Wilcox Desalination Project are well fields, water treatment, integration into the SAWS water distribution system in

[7] Morrison, Kevin, 2008, Personal Communication regarding a preliminary study by LBG-Guyton.

northwest San Antonio, and disposal of backwash and concentrate. The well field consists of brackish water supply wells, collector pipelines, and raw water transmission facilities. Desalination water treatment is planned to use RO technology and will be located in south Bexar County. Finished water will be pumped to Anderson Pump Station in northwest San Antonio. Separate disposal pipelines and facilities are planned for concentrate and backwash water.

Table 4-1 lists the 21 state listed endangered and threatened species, and the 16 federally listed endangered or threatened wildlife and plant species that may occur in Bexar, Wilson, or Atascosa Counties, according to county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species." Inclusion in Table 4-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties. In addition to county lists, Natural Diversity Database (NDD) was reviewed for known occurrences of listed species within or near the project area. This database documents occurrences of several rare plant species including Parks Jointweed (*Polygonella parksii*), Sandhill Woolywhite (*Hymenopappus carrizoanus*), and Elmendorf's Onion (*Allium elmendorfi*) near the project area.

One federally listed endangered species might have potential habitat along the northern most segment of the treated water pipeline, the black-capped vireo (*Vireo atricapillus*). The black-capped vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories.

Several species listed as threatened by the state may also possibly be affected. These include the Texas horned lizard (*Phrynosoma cornutum)*, Texas tortoise (*Gopherus berlandieri)*, and timber/canebrake rattlesnake (*Crotalus horridus)*. The presence or absence of potential habitat does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed well sites and along any pipeline routes. Potential wetland impacts, which are limited to pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291).

Table 4-1.
Important Species* Having Habitat or Known to Occur in
Bexar, Atascosa, or Wilson Counties which Could be Potentially Affected by the
SAWS Local Wilcox Desalination Project

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
A cave obligate crustacean	*Monodella texana*	Subaquatic, underground freshwater aquifers			Resident
A Ground Beetle	*Rhadine exilis*	Karst features in northern Bexar County	LE		Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in northern and western Bexar County	LE		Resident
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Black Bear	*Ursus americanus*	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands,	LE	E	Resident
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone.			Resident
Braken Bat Cave Meshweaver	*Cicurina venii*	Karst features in western Bexar County	LE		Resident
Cascade Caverns salamander	*Eurycea latitans complex*	Endemic, subaquatic in Edwards Aquifer Area		T	Resident
Cave Myotis Bat	*Myotis velifer*	Roosts colonially in caves, rock crevices			Resident
Cokendolpher cave harvestman	*Texella cokendolpheri*	Karst features in north-central Bexar County	LE		Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; springs and waters of caves in Bexar County.		T	Resident
Correll's false dragon-head	*Physostegia correllii*	Wet soils including roadside ditches and irrigation channels.			Resident
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams			Resident
Elmendorf's onion	*Allium elmendorfii*	Endemic, in deep sands			Resident
False spike mussel	*Quincuncina mitchelli*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.			Resident

Table 4-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Golden orb	*Quadrula aurea*	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins			Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands.	LE	E	Resident
Ghost-faced bat	*Mormoops megalophylla*	Roosts in caves, crevices and buildings			Resident
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	Karst features in northwestern Bexar County	LE		Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	Karst features in northwestern Bexar County	LE		Resident
Gray wolf	*Canis lupus*	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Guadalupe Bass	*Micropterus treculi*	Endemic to perennial streams of the Edwards Plateau region			Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in northwestern Bexar County	LE		Resident
Hill Country wild-mercury	*Argythamnia aphoroides*	Shallow clays over limestone			Resident
Indigo snake	*Drymarchon corais*	Dense riparian corridors		T	Resident
Interior least tern	*Sterna antillarum athalassos*	Nests along sand and gravel bars in braided streams	LE	E	Resident
Madla Cave Meshweaver	*Cicurina madla*	Karst features in northern Bexar County	LE		Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	Skipper larvae usually feed inside a leaf shelter.			Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; only known from two wells penetrating the Edwards Aquifer			Resident
Mountain Plover	*Charadrius montanus*	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Nueces crayfish	*Procambarus nueces*	Riparian edges of one small stream tributary to the Nueces River			Resident

Table 4-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Ocelot	*Leopardus pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	LE	E	Resident
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Peregrine falcon	*Falco peregrinus anatum (American)*	Open county; cliffs.	DL	E	Nesting/Migrant
	Falco peregrinus tundrius (Arctic)		DL	T	
Pistolgrip	*Tritogonia verrucosa*	Aquatic, stable substrate.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas.			Resident
Rawson's metalmark	*Calephelis rawsoni*	Moist areas in shaded limestone outcrops			Resident
Red Wolf	*Canis rufus*	Extirpated.	LE	E	Historic Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	Karst features in north-central Bexar County	LE		Resident
Rock pocketbook	*Arcidens confragosus*	Mud and sand, Red through Guadalupe River basins.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations.			Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	Moderately open prairie-brushland.			Resident
Texas fatmucket	*Lampsilis bracteata*	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands.		T	Resident
Texas pimpleback	*Quadrula petrina*	Mud, gravel and sand substrates, Colorado and Guadalupe river basins			Resident

Table 4-1 (Concluded)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Texas Salamander	*Eurycea neotenes*	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages in Bexar County			Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory.		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes.		T	Resident
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Potential Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.		T	Resident
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, often near watercourses		T	Resident

- LE/LT=Federally Listed Endangered/Threatened
- DL, PDL=Federally Delisted/Proposed for Delisting
- E, T=State Listed Endangered/Threatened
- Blank = Rare, but no regulatory listing status

Source: TPWD, Annotated County List of Rare Species, Bexar County, October 30, 2007, Atascosa County, October 30, 2007, and Wilson County, October 30, 2007.

4.4 Engineering and Costing

The engineering and costing analysis for SAWS Local Wilcox Desalination Project includes all facilities required for water production from the Wilcox Aquifer in Bexar, Atascosa, and Wilson Counties, water treatment, delivery to SAWS water distribution system in northwest San Antonio, and disposal of backwash and concentrate. The well field consists of brackish water supply wells, collector pipelines, and raw water transmission facilities. Desalination water treatment is planned to use Reverse Osmosis (RO) technology and will be located in south Bexar County. Finished water will be pumped to Anderson Pump Station in northwest San Antonio. Separate disposal pipelines and facilities are planned for concentrate and backwash water. Preliminary engineering and costing by SAWS and HDR were based on an initial location of the desalination water treatment plant being in the vicinity of US 281 and Loop 1604. SAWS is proposing to locate the plant next to their ASR facility in South Bexar County. As needed, engineering designs and cost estimates will be revised, if and when, this strategy becomes part of the water management plan.

For planning purposes, Wilcox wells are assumed to yield water with a TDS concentration that averages 1,400 mg/L. The required secondary Maximum Contaminant Level (MCL) for TDS is 1,000 mg/L. The blended finished water is expected to have a TDS concentration of about 450 – 500 mg/L. Pretreatment prior to the desalination process will include filtration and possibly other processes to remove particulates such as iron or manganese and to condition the water for optimal desalination by RO. Pilot testing of RO membranes will refine necessary pretreatment facilities. Preliminary plans are to dispose of the concentrate from the desalination process by injection into deep wells in the area. Normally, backwash is processed on-site with the sludge going to a landfill. However, in consideration of the preliminary design and the volume of the brackish water, a direct, off-site disposal is planned. The disposal point is currently being studied and may include the SAWS Dos Rios Water Treatment Plant.

A cost estimate provided by SAWS for the SAWS Local Wilcox Desalination Project is shown in Table 4-2. SAWS provided HDR with spreadsheets with cost as of July 2007. The first spreadsheet is a “SAWS Desalination Plant Conceptual Construction Cost Estimate: 25 MGD” and the second spreadsheet is “Cost Estimate for Brackish Groundwater, 28,000 acft, Cost Basis

Table 4-2.
Cost Estimate Summary for SAWS Local Wilcox Desalination Project (Provided by SAWS) (July 2007 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Well Fields, includes Wells and Collector Pipelines (27 Wells)	$60,309,000
Raw Water Pump Stations	$3,601,000
Raw Water Transmission Pipelines (10-24 in dia., 14 miles)	$10,958,000
Integration Pump Station (25 MGD)	$7,000,000
Integration Pipeline (36 in dia, 29 mi)	$42,239,000
Concentrate Disposal Wells (6 Wells)	$14,110,000
Concentrate and Backwash: Pump Stations and Pipelines (18 in, 31 mi)	$23,605,000
Water Treatment Plant (25 MGD)	$35,401,000
Total Capital Cost	**$197,223,000**
Engineering, Legal Costs and Contingencies	$87,676,000
Environmental & Archaeology Studies and Mitigation	$500,000
Land Acquisition and Surveying	$5,283,000
Interest During Construction (1 years)	$8,551,000
Total Project Cost	**$299,233,000**
Annual Costs	
Debt Service (4.8 percent, 30 years)	$19,024,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$6,702,000
Water Treatment Plant	$4,113,000
Pumping Energy Costs	$7,805,000
Groundwater Leases (17,750 acft @ $40/acft)	$710,000
Groundwater District Fees (17,750 acft/yr @ $8.15acft)	$145,000
Total Annual Cost	**$38,499,000**
Available Project Yield (acft/yr)	28,000
Annual Cost of Water ($ per acft)	$1,375
Annual Cost of Water ($ per 1,000 gallons)	$4.22

July 2007." The engineering and costing analysis includes a brackish well field with 27 wells with a production capacity of about 30 MGD. Based on various parameters, SAWS estimates about half of the produced water will be come from the desalination plant and the other half from the raw water. According to SAWS, preliminary plans are to operate the plant as a base load operation and to produce 25 MGD on a continuous basis. Well pumps will be sized to deliver raw water directly to booster pump stations. The raw water collection pipelines will vary in diameter and be about 20 miles long. The raw water transmission pipelines will be about 19 miles long. The project's integration pipeline from the water treatment plant to northwest San Antonio will be 36 inch in diameter and about 28 miles long and require a booster station in the vicinity of Lackland or Marbach. The concentrate from the RO unit will be disposed of by deep well injection in a depleted oil and gas field. SAWS plans for concentrate disposal include a pump station, a pipeline about 17 miles long and 6 deep injection wells. Finally, the backwash will require a pump station and a pipeline that is assumed to be 14 miles long. These estimates are based on SAWS initial plans and will change as their plans are revised.

As shown in Table 4-2, SAWS cost estimates for the Local Wilcox Desalination Project includes a total capital cost of $197,233,000 and a total project cost of about $299,233,000. Annual operating cost, including debt service, leases payments to property owners for groundwater pumping, and groundwater district fees, to be about $38,499,000. With a project yield of 28,000 acft/yr (25 MGD), annual unit cost of $1,375 per acft/yr.

For consistency in consideration of multiple water management strategies evaluated in the regional water planning process, an alternative cost estimate using standard Region L procedures and technical assumptions is presented in Table 4-3. This cost estimates shows a total capital cost of $175,033,000 and a total project cost of about $264,882,000. Annual operating cost, including debt service, groundwater leases, and groundwater district fees, to be about $33,364,000. With a project yield of 28,000 acft/yr (25 MGD), annual unit cost of $1,192 per acft/yr. Instances where the SAWS estimate is somewhat higher than Region L are: pipeline unit costs; water treatment plants; backwater disposal system; engineering, legal and contingencies; operation and maintenance of pump stations and pipelines; and power costs. Instances where the Region L estimate is higher than the SAWS estimate includes: pump stations; and environmental studies and mitigation. The Region L cost estimating procedures do not itemize the cost of disposing of backwash from the water treatment plants. The preliminary design by Region L requires about 29 MGD of raw brackish groundwater, blends about 35 percent of the raw water into the final product water, and estimates the desalination water treatment plant operates at 80 percent efficiency.

Table 4-3.
Cost Estimate Summary for SAWS Local Wilcox Desalination Project using Region L Procedures (Second Quarter 2007 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Well Fields, includes Wells and Collector Pipelines (27 Wells)	$47,081,000
Raw Water Pump Stations	$8,556,000
Raw Water Transmission Pipelines (24-42 in dia., 18.2 miles)	$12,679,000
Integration Pump Stations (25 MGD)	$13,247,000
Integration Pipeline (42 in dia, 29 mi)	$38,357,000
Concentrate Disposal Wells and Injection Pumps (6 Wells)	$14,914,000
Concentrate Pump Station and Pipelines (20 in, 17 mi)	$10,229,000
Water Treatment Plant (25 MGD)	$29,970,000
Total Capital Cost	**$175,033,000**
Engineering, Legal Costs and Contingencies	$58,272,000
Environmental & Archaeology Studies and Mitigation	$3,280,000
Land Acquisition and Surveying (316 acres)	$8,676,000
Interest During Construction (2 years)	$19,621,000
Total Project Cost	**$264,882,000**
Annual Costs	
Debt Service (6 percent, 30 years)	$19,243,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$1,802,000
Water Treatment Plant	$6,442,000
Pumping Energy Costs (53615976 kW-hr @ 0.09 $/kW-hr)	$4,825,000
Groundwater Leases (21,857 acft/yr @ $40/acft)	$874,000
Groundwater District Fees (21,857 acft/yr @ $8.15 per acft)	$178,000
Total Annual Cost	**$33,364,000**
Available Project Yield (acft/yr)	28,000
Annual Cost of Water ($ per acft)	$1,192
Annual Cost of Water ($ per 1,000 gallons)	$3.66

In summary, the cost estimate using Region L procedures shows the unit water cost to be about 13 percent lower than the SAWS estimate. This is not to say that one estimate is more accurate than the other estimate. Finally, it's important to note that SAWS is considering modifications to these plans and is conducting additional research on the feasibility and design of this strategy.

4.5 Implementation Issues

Implementation of the SAWS Local Wilcox Desalination Project includes the following issues:

- Verification of available groundwater water quantity and well productivity of the Wilcox Aquifer in southern Bexar, northern Atascosa, and western Wilson Counties;
- Potential adverse impacts on other aquifers (additional research regarding potential interaction between the Wilcox and Carrizo formations has been suggested);
- Verification of Wilcox Aquifer water quality for concentrations of the dissolved constituents such as TDS, chloride, and sulfate; and to ensure that particulates that would require pretreatment removal such as iron or manganese are not present;
- Verification that desalinated Wilcox Aquifer water is compatible with other water sources and will meet all water quality requirements in distribution system;
- Permitting Class 1 disposal wells for deep well injection of desalination concentrate;
- Experience in operating and maintaining a desalination water treatment plant;
- Brine Disposal Discharge Permits by TCEQ;
- Securing permits from groundwater district (Atascosa and Wilson Counties); and
- Securing water rights to the Wilcox Aquifer.

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5.0 Edwards Brackish Desalination Project

5.1 Description

The Edwards Brackish Desalination Project is a water management strategy based on the development of brackish groundwater from the Edwards Aquifer in southern Bexar County (Figure 5-1). The concept of expanding use of the Edwards by pumping and treating brackish groundwater has been of interest to some water planners in Bexar County for many years. For this strategy, the target location of the well field was selected on the basis of placing the well field in the updip section of the saline part of the Edwards where there is a perceived separation from the freshwater part of the Edwards Aquifer, yet not so deep to encounter very saline water and great well depths. The planned location for the well field is between Texas Highway 16 and U.S. Highway 281 and south of Loop 1604. The planned location of the water treatment plant would be on Highway 16 and about 2 miles south of Loop1604.

The selected strategy is sized to produce 18,000 acft/yr (16 MGD). Preliminary design for this strategy includes: a well field that draws water from the brackish part of the Edwards Aquifer, collection pipelines for delivery of raw well water to the nearby desalination water treatment plant, water treatment plant, transmission facilities (storage, pipelines and pump stations) to deliver the treated water to the SAWS Anderson Pump Station, and transmission facilities and deep wells to dispose of concentrate from the water treatment plant. Figure 5-1 illustrates the general layout of the facilities for the strategy.

The Edwards Brackish Desalination Project is located in the jurisdiction of the Edwards Aquifer Authority (EAA) and must comply with their rules. One of the issues in developing the project is that EAA has fully allocated (permitted) all of the available water supply from the Edwards Aquifer. As a result, development of the project must include the purchase and transfer of existing water rights.

5.2 Available Yield

Assessment of the potential yield of brackish water from the Edwards was based on compiling and studying technical reports on the Edwards Aquifer saline-water zone and interviewing SAWS staff, their consultants, and scientists with the USGS with regard to SAWS long-term test drilling program along the transition zone between the freshwater and saline zone

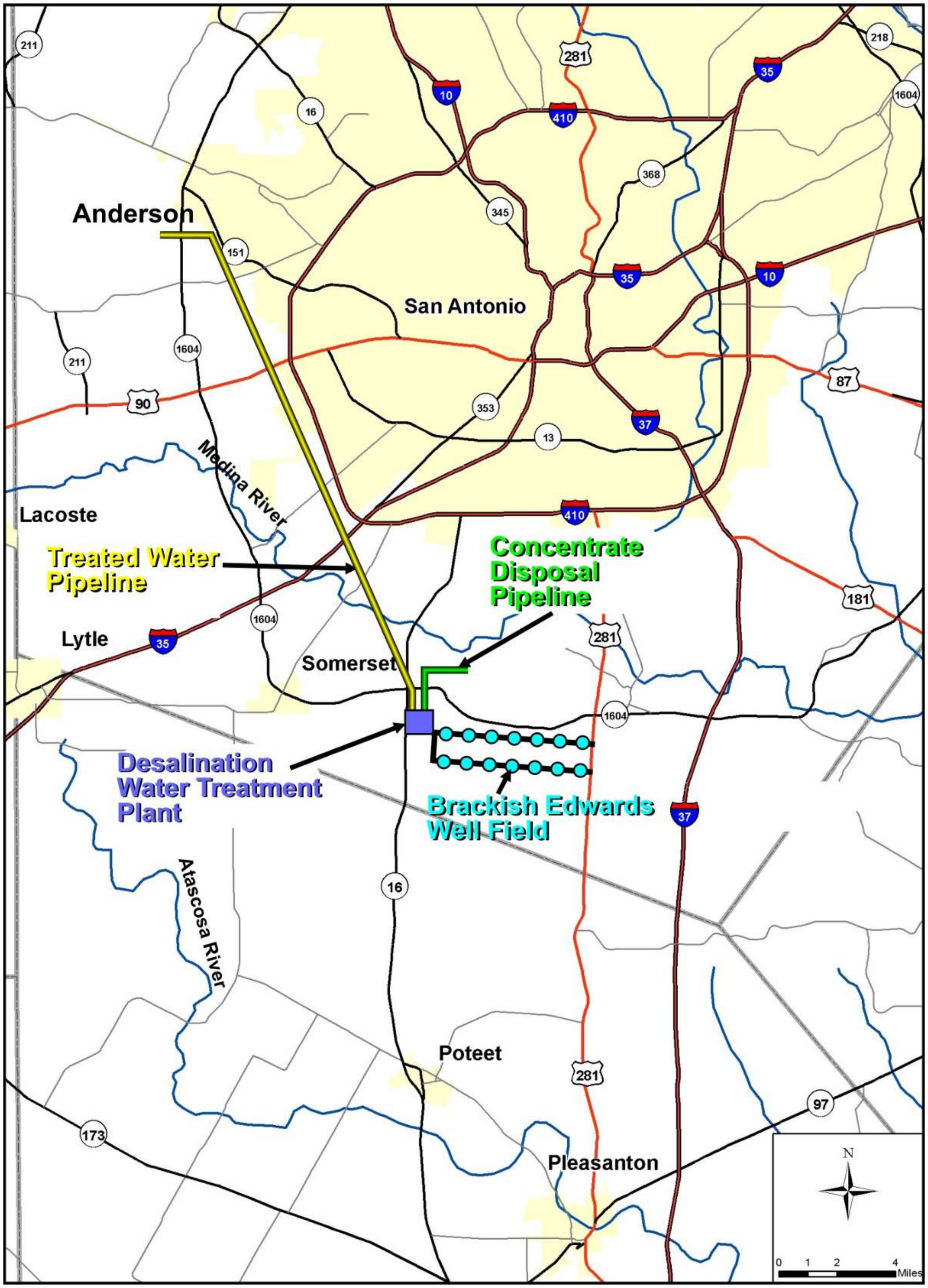

Figure 5-1. Edwards Brackish Desalination Project

being divided between a hydrologically active area and a hydrologically stagnant area. Their data and analyses show the active or transition zone to extend from the so-called bad-water line to about 40 miles downdip. Further downdip, the area is considered to be stagnant. Groschen and Buszka[8] further divided the active area into one subarea that is relatively near the downdip limit of the freshwater zones of the Edwards and a second subarea that is farther downdip and has shallow oil and gas wells. The concentration of TDS in the updip subarea is generally between 2,000 and 4,500 mg/L. In the downdip subarea, the TDS concentrations generally range from 13,000 to 25,000 mg/L. In the stagnant area, the TDS concentrations exceed 125,000 mg/L. Of interest, in the updip zone of the active area is a well in southern Bexar County. The data show the well to be 2,900 ft deep and produced water with a TDS concentration of 4,360 mg/L and at a temperature of 97°F.

The geologic structure of the saline part of the Edwards is described by Maclay (1995)[9]. A map showing the structural surface of the top of the Edwards and the location of the "Bad-Water Line" is shown in Figure 5-2. Allowing for a land surface elevation of about 500 ft-msl and 600 ft penetration into the Edwards Aquifer, well depths in south Bexar County would be about 4,500-5,000 ft deep. Edwards Aquifer saline wells near the Bexar, Atascosa, Wilson County line would be 16-18 miles from the "Bad-Water Line." Figure 5-2 shows the "Bad-Water Line" along the Luling Fault Zone and the strike of the top of the Edwards. The Luling Fault Zone is a series faults with the downthrown block being to the southeast and causes a major interruption to the continuity of the Edwards Aquifer.

Groundwater movement in the saline zone of the Edwards is not explicitly defined on the basis of pressure maps or measurements of recharge and discharge. According to Maclay and Land (1988)[10], recharge to and discharge from the saline zone occurs across the downdip limit of the freshwater in the Edwards Aquifer. The amount of recharge estimated to the saline zone is less than 10 percent of the total recharge to the Edwards.

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[8] Groschen, G.E. and Buszka, P.M., 1997, Hydrogeologic framework and geochemistry of the Edwards Aquifer saline-water zone, south-central Texas: U.S. Geological Survey Water Resources Investigation Report 97-4133.
[9] Maclay, R.W., 1995, Geology and hydrology of the Edwards Aquifer in the San Antonio area, Texas: USGS Water-Resources Investigations Report 95-4186.
[10] Maclay, R.W., and Land, L.F., 1988, Simulation of flow in the Edwards Aquifer , San Antonio region, Texas: USGS Water Supply Paper 2336-A.

A search for information on aquifer hydraulic properties resulted in approximate estimates of hydraulic conductivity. Maclay and Land estimated the hydraulic conductivity to be 2-3 orders of magnitude less than in the freshwater zone. They estimated the transmissivity of the Edwards freshwater zone to be about 2 million sqft/day. For a three orders of magnitude decrease, the transmissivity of the saline zone would be about 2,000 sqft/day. A consultant's report[11] estimated the transmissivity of the saline zone near SAWS Artesia pump station to be about 10,760 sqft/day. For an aquifer with this range of hydraulic properties, a fully developed well could easily produce about 1,000 gpm with drawdown between 75 and 150 ft.

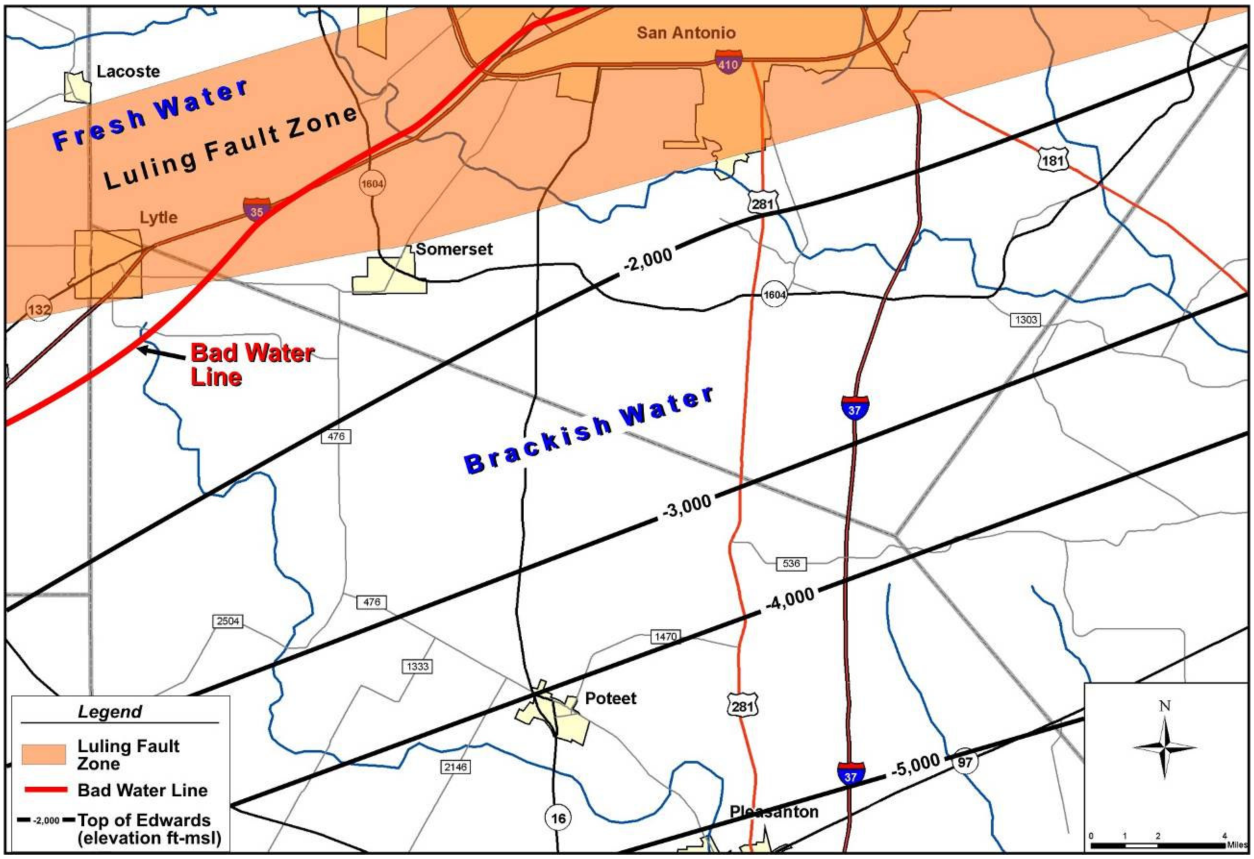

Figure 5-2. Map Showing Features of Edwards Aquifer Brackish Zone

[11] William F Guyton Associates, Inc., 1986, Drilling, construction, and testing of monitor wells for the Edwards Aquifer bad-water line experiment: Consultant report to the San Antonio City Water Board.

One major topic of concern developed during the construction of a test well for the saline zone of the Edwards near the town of Lytle by SAWS. According to John Waugh (SAWS, personal communications, 2008) and Bill Stein (LBG-Guyton Associates, personal communications, 2008), the test well began producing high levels of hydrogen sulfide gas during the drilling of the Edwards Aquifer. Because of safety concerns, the test well was not completed. Thus, a very limited amount of data was collected before the well was cemented shut. The limited water quality data suggests sulfate concentrations were greater than 1,000 mg/L and TDS concentrations were about 2,000 mg/L. The Groshchen and Buszka (1997) study reports that the geochemistry of the Edwards Aquifer in the transition zone is very conducive to producing hydrogen sulfide gas.

Another technical concern with the development of Edwards saline water is the potential for freshwater to move from the Edwards across the "Bad Water Line" and into the brackish well field. There are many faults in the area between the planned brackish well field and the freshwater zone of the Edwards; however, there is not sufficient information to explicitly determine what portion, if any, of the water budget from the brackish well field will come from the freshwater section of the Edwards Aquifer. However, considering the geology, hydrology, and water chemistry of the saline zone, it appears that, in time, the brackish well field will cause some freshwater to be lost from the Edwards Aquifer.

There is a continuing concern on the potential for the loss or migration of freshwater from the Edwards into saline zone as a brackish well field is developed and operated. To address this concern, a detailed data collection and hydrogeologic analysis program is needed for further evaluation of this water management strategy.

5.3 Environmental Issues

Edwards Brackish Desalination Project involves the development of a well field in the brackish portion of Bexar County, raw water transmission pipelines, a desalination water plant near State Hwy 16 and Loop 1604, treated water transmission to Anderson Pump Station, and concentrate disposal pipeline and wells. The facilities include a major west-side pipeline to the Anderson Pump Station.

Table 5-1 lists the 21 state listed endangered and threatened species, and the 16 federally listed endangered or threatened wildlife and plant species that may occur in Bexar County.

Table 5-1
Important Species* Having Habitat or Known to Occur in Bexar County which Could be Potentially Affected by the Edwards Brackish Desalination Project

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
A cave obligate crustacean	*Monodella texana*	Subaquatic, underground freshwater aquifers			Resident
A Ground Beetle	*Rhadine exilis*	Karst features in northern Bexar County	LE		Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in northern and western Bexar County	LE		Resident
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Black Bear	*Ursus americanus*	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands,	LE	E	Resident
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone.			Resident
Braken Bat Cave Meshweaver	*Cicurina venii*	Karst features in western Bexar County	LE		Resident
Cascade Caverns salamander	*Eurycea latitans complex*	Endemic, subaquatic in Edwards Aquifer Area		T	Resident
Cave Myotis Bat	*Myotis velifer*	Roosts colonially in caves, rock crevices			Resident
Cokendolpher cave harvestman	*Texella cokendolpheri*	Karst features in north-central Bexar County	LE		Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; springs and waters of caves in Bexar County.		T	Resident
Correll’s false dragon-head	*Physostegia correllii*	Wet soils including roadside ditches and irrigation channels.			Resident
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams			Resident
Elmendorf’s onion	*Allium elmendorfii*	Endemic, in deep sands			Resident
False spike mussel	*Quincuncina mitchelli*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.			Resident

Table 5-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
Golden orb	*Quadrula aurea*	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins			Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands.	LE	E	Resident
Ghost-faced bat	*Mormoops megalophylla*	Roosts in caves, crevices and buildings			Resident
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	Karst features in northwestern Bexar County	LE		Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	Karst features in northwestern Bexar County	LE		Resident
Gray wolf	*Canis lupus*	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Guadalupe Bass	*Micropterus treculi*	Endemic to perennial streams of the Edwards Plateau region			Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in northwestern Bexar County	LE		Resident
Hill Country wild-mercury	*Argythamnia aphoroides*	Shallow clays over limestone			Resident
Indigo snake	*Drymarchon corais*	Dense riparian corridors		T	Resident
Interior least tern	*Sterna antillarum athalassos*	Nests along sand and gravel bars in braided streams	LE	E	Resident
Madla Cave Meshweaver	*Cicurina madla*	Karst features in northern Bexar County	LE		Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	Skipper larvae usually feed inside a leaf shelter.			Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; only known from two wells penetrating the Edwards Aquifer			Resident
Mountain Plover	*Charadrius montanus*	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Nueces crayfish	*Procambarus nueces*	Riparian edges of one small stream tributary to the Nueces River			Resident

Table 5-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Ocelot	*Leopardus pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	LE	E	Resident
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Peregrine falcon	*Falco peregrinus anatum (American)*	Open county; cliffs.	DL	E	Nesting/Migrant
	Falco peregrinus tundrius (Arctic)		DL	T	
Pistolgrip	*Tritogonia verrucosa*	Aquatic, stable substrate.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas.			Resident
Rawson's metalmark	*Calephelis rawsoni*	Moist areas in shaded limestone outcrops			Resident
Red Wolf	*Canis rufus*	Extirpated.	LE	E	Historic Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	Karst features in north-central Bexar County	LE		Resident
Rock pocketbook	*Arcidens confragosus*	Mud and sand, Red through Guadalupe River basins.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations.			Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	Moderately open prairie-brushland.			Resident
Texas fatmucket	*Lampsilis bracteata*	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands.		T	Resident
Texas pimpleback	*Quadrula petrina*	Mud, gravel and sand substrates, Colorado and Guadalupe river basins			Resident

Table 5-1 (Concluded)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Texas Salamander	*Eurycea neotenes*	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages in Bexar County			Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory.		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes.		T	Resident
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Potential Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.		T	Resident
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, often near watercourses		T	Resident

- LE/LT=Federally Listed Endangered/Threatened
- DL, PDL=Federally Delisted/Proposed for Delisting
- E, T=State Listed Endangered/Threatened
- Blank = Rare, but no regulatory listing status

Source: TPWD, Annotated County List of Rare Species, Bexar County, October 30, 2007, Atascosa County, October 30, 2007, and Wilson County, October 30, 2007.

According to county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species." Inclusion in Table 5-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties. In addition to county lists, the Natural Diversity Database (NDD) map data was reviewed for known occurrences of listed species within or near the project area. This database documents occurrences of several rare plant species including Parks Jointweed (*Polygonella parksii*), Sandhill Woolywhite (*Hymenopappus carrizoanus*), and Elmendorf's Onion (*Allium elmendorfi*) near the project area.

One federally listed endangered species might have potential habitat within the project area, the black-capped vireo (*Vireo atricapillus*). The black-capped vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories.

Several species listed as threatened by the state may also possibly be affected. These include the Texas horned lizard (*Phrynosoma cornutum)*, Texas tortoise (*Gopherus berlandieri)*, and timber/canebrake rattlesnake (*Crotalus horridus)*. The presence or absence of potential habitat does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed well sites and along any pipeline routes. Potential wetland impacts, which are limited to pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291).

5.4 Engineering and Costing

The Edwards Brackish Desalination Project is sized and designed to produce 18,000 acft/yr (16 MGD) of potable water at a constant rate.

The engineering and costing analysis for this project includes all facilities required for water production from the Edwards Aquifer in southern Bexar County, water treatment, transmission to Anderson Pump Station, disposal of concentrate, and purchase of water rights. The well field consists of brackish water supply wells, collector pipelines, and raw water transmission facilities. Desalination water treatment is expected to use RO technology and will be located adjacent to the well field. Finished water will be pumped to SAWS Anderson Pump Station. Using SAWS plans for their Local Wilcox Desalination Project as an example, the concentrate will be injected into deep wells in an abandoned oil and gas well field in the area.

The TDS concentration of the Edwards saline water is estimated to be about 4,500 mg/L. The required secondary Maximum Contaminant Level (MCL) for TDS is 1,000 mg/L. To approximate the TDS concentrations of fresh Edwards water, preliminary designs have 95 percent of the raw water from the well field being processed by the desalination component of the water treatment plant to remove dissolved solids and approximately 5 percent bypasses the RO units, which will be blended with permeate from the RO unit. The resulting water quality is about 300 mg/L of TDS. Considering water losses to concentrate from the RO process and backwash, the yield of the strategy is expected to be about 75 percent efficient. Thus, a 21 MGD well field is needed to produce 16 MGD of potable water. Pretreatment prior to the desalination process will include filtration and possibly other processes to condition the water for optimal desalination by RO.

The cost estimate for the Edwards Brackish Desalination Project is shown in Table 5-2. The engineering and costing analysis includes a brackish well field with 14 wells with a total production capacity about 21 MGD, a water treatment plant capable of producing 16 MGD with about 15 MGD coming from the RO unit, and purchase of Edwards water rights. Preliminary plans are to operate the plant as a base load operation. Well pumps will be sized to deliver raw water directly to the water treatment plant. The project's treated water pipeline from the water treatment plant Anderson Pump Station will be 33 inch in diameter and about 21.9 miles long. Given the uncertainty of attempting to increase the Edwards Aquifer permit cap and modify critical period actions established by the Texas Legislature, costs for the purchase of existing pumpage rights is included, and are estimated to be $5,500 per acft. Because of water losses in the desalination process, about 23,600 acft is needed to provide an 18,000 acft/yr supply of potable water. During Stage IV of Critical Period Management, Edwards permit in the San Antonio Pool are required to reduce their withdrawals by 40 percent. Thus, to provide a firm supply of 23,594 acft during the most severe conditions, water rights for 39,325 acft/yr of Edwards water in the San Antonio Pool are required. The disposal of concentrate is expected to require about five wells and an injection pump station. The total length of pipelines for disposal of concentrate and backwash is estimated to be about 18 miles long. As shown in Table 5-2, desalination of Edwards' brackish groundwater strategy would provide an average daily supply of 18,000 acft/yr (16 MGD) at an annual unit cost of $2,103 per acft/yr.

5.5 Implementation Issues

Implementation of the Edwards Brackish Desalination Project strategy includes the following issues:

- Assessment of safety issues related to the raw water containing hydrogen sulfide gas. This includes the construction and development of wells and in handling the raw water;
- The EAA has fully allocated all the available water from the Edwards. Thus, the supply of brackish Edward groundwater must be purchased from existing permit holders. Revisions to statutory permit cap for the Edwards Aquifer for brackish water projects is considered to be very unlikely;
- Verification of available groundwater water quantity and well productivity of the Edwards aquifer in southern Bexar, northern Atascosa, western Wilson, and northern Frio Counties;
- Verification of Edwards Aquifer water quality for both concentrations of the dissolved constituents such as TDS, chloride, and sulfate; and to ensure that particulates that would require pretreatment removal such as iron or manganese are not present;
- Verification that desalinated Edwards Aquifer water is compatible with other water sources and will meet all water quality requirements in the end user's distribution system;
- Verification through studies and research that brackish zone is essentially isolated from the freshwater zone of the Edwards;
- Permitting Class 1 disposal wells for deep well injection of desalination concentrate;
- Brine Disposal Discharge Permits by TCEQ;
- Permitting with Edwards Aquifer Authority; and
- Securing water rights to in the Edwards Aquifer.

Table 5-2.
Cost Estimate Summary for Edwards Brackish Desalination Project
(Second Quarter 2007 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Dam and Reservoir	$0
Distribution Pump Station and Storage at WTP	$6,825,000
Concentrate Pump Station and Storage at WTP	$1,681,000
Treated Water Pipeline (33 inch, 21.9 miles)	$21,722,000
Concentrate Disposal (Pipeline, Wells and Misc (24 inch, 18 mile)	$24,136,000
Well Field Collection Pipelines (12-24 inch, 14 miles	$4,796,000
Well Field (14 Wells)	$30,174,000
Water Treatment Plant (Desalination, 16 MGD)	$29,083,000
Distribution	$0
Relocations & Other	$0
Total Capital Cost	**$118,417,000**
Engineering, Legal Costs and Contingencies	$40,009,000
Environmental & Archaeology Studies and Mitigation	$2,194,000
Land Acquisition and Surveying	$4,923,000
Interest During Construction (1 years)	$13,264,000
Purchase of Edwards Water Rights (39,324 acft/yr)	$216,284,000
Total Project Cost	**$395,091,000**
Annual Costs	
Debt Service (6 percent, 30 years)	$28,721,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$1,038,000
Dam and Reservoir	$0
Water Treatment Plant	$6,060,000
Pumping Energy Costs (0.09 $/kW-hr)	$2,031,000
Total Annual Cost	**$37,850,000**
Available Project Yield (acft/yr)	18,000
Annual Cost of Water ($ per acft)	$2,103
Annual Cost of Water ($ per 1,000 gallons)	$6.45

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Appendix A
Wells from the Texas Water Development Board Well Database

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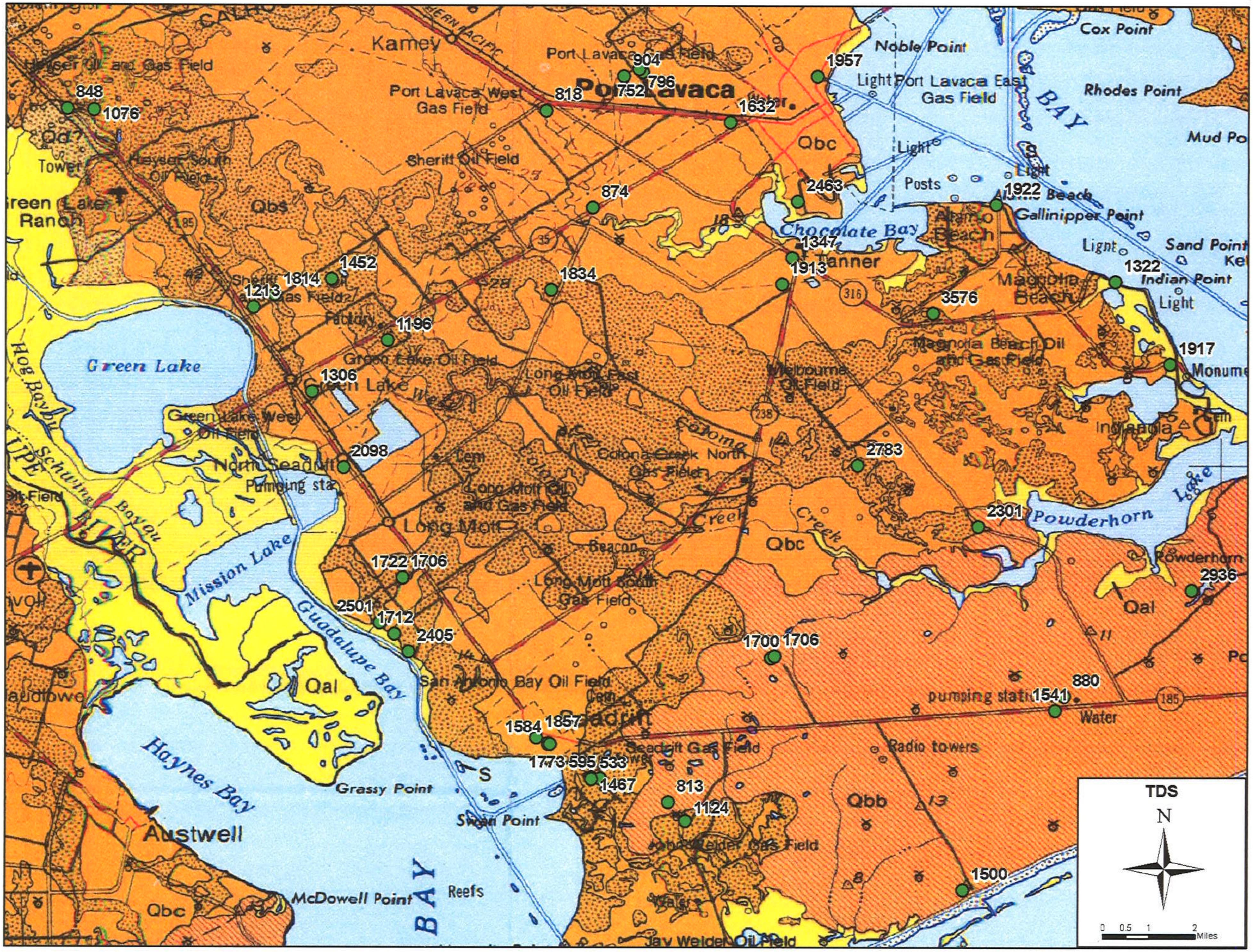
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Port Lavaca West Gas Field
Port Lavaca East Gas Field
Sheriff Oil Field
Noble Point
Cox Point
Rhodes Point
BAY
Chocolate Bay
Gallinipper Point
Sand Point
Indian Point
Magnolia Beach
Magnolia Beach Oil and Gas Field
Green Lake
Green Lake Oil Field
Green Lake West Oil Field
Long Mott East Oil Field
Colona Creek North Gas Field
Long Mott Oil and Gas Field
Long Mott
Long Mott South Gas Field
Powderhorn Lake
Qbc
Qbs
Qbb
Qal
Mission Lake
Guadalupe Bay
San Antonio Bay Oil Field
Seadrift Gas Field
Haynes Bay
Grassy Point
Swan Point
McDowell Point
Reefs
Austwell
Hog Bayou
Schwings Bayou
pumping station
Water
Radio towers
Jay Welder Oil Field
Heyser South Oil Field
Towers
Green Lake Ranch

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Appendix B
Comments from Texas Water Development Board and Responses

ATTACHMENT 1

TWDB Contract No. 0704830697

Region L, Region-Specific Studies 1-5:

<u>TWDB Comments on Draft Final Region-Specific Study Reports:</u>
1) Lower Guadalupe Water Supply Project for GBRA Needs
2) Brackish Groundwater Supply Evaluation
3) Enhanced Water Conservation, Drought Management and Land Stewardship
4) Environmental Studies
5) Environmental Evaluations of Water Management Strategies

Region-Specific Study 2: Brackish Groundwater Supply Evaluation

1. Scope of Work item 5 includes documentation of meetings. Please include documentation in the report for meetings conducted as part of the project.

<u>Response</u> – No particular documentation is necessary, as study-specific meetings were not held regarding Brackish Groundwater Supply Evaluation.

2. Scope of Work item 6 includes making recommendations. Please include a section on recommendations as appropriate.

<u>Response</u> – No particular recommendations are required as the evaluation included only an analysis of four case-study projects.

3. Please correct the name Refugio County Groundwater Conservation District or RCGCD to Refugio Groundwater Conservation District or RGCD throughout the report.

<u>Response</u> – The name and abbreviation of the groundwater conservation district will be corrected.

4. Page 41: under Implementation Issues. Text only states "coordination with groundwater district". For consistency, suggest adding the same language on this page that was on page 27 - to include "Permitting from the groundwater district".

<u>Response</u> – The bullet labeled "coordination with groundwater district" will be changed to "Securing permits from groundwater district (Atascosa and Wilson Counties)."

5. Page 5, paragraph 1: For clarity, please consider defining brackish and saline water, in terms of total dissolved solids (TDS), in the opening section of the report.

<u>Response</u> – This comment applies to all four projects. It is suggested that the definition be placed in Section 1.0 on Page 1. As such, the following language will be inserted immediately following the first sentence in Paragraph 2 on Page 1 – *"For this study, brackish groundwater is defined as groundwater with salinity greater than secondary drinking water standards (500 ppm Cl and 1,000 ppm TDS) and less that 5,000 ppm TDS, while saline groundwater is groundwater with salinity greater than 5,000 ppm TDS."*

6. Page 5, paragraph 1: Please consider including in an appendix or as an attachment some geophysical logs that were used to identify brackish groundwater in the area.

<u>Response</u> – Brackish groundwater was primarily identified using water quality data and well features information from the TWDB well database. Maps showing the pertinent information will be added as an appendix.

7. Pages 13, 27, 41 and 54: As stated, it is not clear what the anticipated implementation issues of TCEQ regulations are. Please elaborate or specify the TCEQ regulations that are anticipated to be issues in the implementation of the projects.

<u>Response</u> – Regulations by TCEQ include brine disposal discharge permits. The bullet will be changed to read *"Brine Disposal Discharge Permits by TCEQ."*

8. Page 31, last paragraph of section 4.2, lines 2-3: Please clarify the sentence stating that there are no groundwater districts to regulate well spacing and production in Bexar County. Bexar County does have a district, the Edwards Aquifer Authority, but its authority is limited to the Edwards Aquifer.

<u>Response</u> – The sentence will be changed to read: *"In Bexar County, there is no groundwater district to regulate well spacing and production in the Wilcox Aquifer."*

9. Page 37, paragraph 1, lines 10-11: The sentence "Since, SAWS…….Bexar County." is grammatically incomplete.

<u>Response</u> – The sentence will be changed to read: *"SAWS is proposing to locate the plant next to their ASR facility in South Bexar County."*